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PIPELINE FLOW CHARACTERISTICS OF THIXOTROPIC FLUIDS

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The undersigned cerfity that they have read, and recommend to the Faculty of Graduate Studies for acceptance a thesis entitled PIPELINE FLOW CHARACTERISTICS OF THIXOTROPIC FLUIDS by Jimmy P. Batycky in partial fulfilment of the requirements for the degree of Master of Science in Chemical Engineering.

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ABSTRACT

A computer program was developed to calculate the change in pressure that a thixotropic fluid, under conditions of laminar flow, experiences while flowing along a pipe. Calculation of the total pressure drop in a selected length of pipe at various times after start-up led to a demonstration of its transient nature.

Shear stress decay data were interpolated and integrated to yield radial incremental flow rates corresponding to a specified total - thus satisfying an over-all volumetric flow rate balance. The incremental flows were bounded by streamlines which were allowed to adjust radially as flow proceeded down the pipe. This movement of streamlines enabled maintenance of the constraint requiring that no fluid cross a streamline - hence sustaining each individual flow rate at a constant value. The movement of fluid radially accommodated its thixotropic characteristic; that is, the shear rate and consequently the velocity exhibited at any point was dependent on both the length of time that a filament of liquid had undergone shear and the shear stress that was applied to it.

By assuming that radial flow was small in comparison to longitudinal flow at any position in the pipe, the shear stress profile was approximated as linear across the flow diameter. This allowed direct calculation of the pressure drop gradient from the wall shear stress. Integration of

this gradient for each selected shear duration at a constant flow rate (from start-up to steady state) yielded transient values of line pressure drop.

Using the same flow durations at three or four volumetric flow rates, a curve representing the change in pressure drop with flow rates was plotted at each time after start-up. Then a pump characteristic of pressure drop versus flow rate was superimposed. Intersection of this curve by each of the previous ones characterized a transient response of flow rate and of pressure drop. The exact response could be controlled by substituting various pumps on the same plot.

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INTRODUCTION

The design of pipelines for the transport of fluids requires an accurate prediction of pump power requirements. The magnitudes of pressure drops needed to initiate and to maintain flow, besides depending on such factors as pipe diameter and volumetric flow rate, are also a function of the rheological properties of the fluids.

Most fluids are easily described, in a rheological sense, through mathematical approximations(1). This permits the use of a simple calculation in arriving at a predicted value of pressure drop. The pressure drop, however, may be required at a number of flow rates, or the rheological data may not be readily approximated, or even the geometric configuration of the flow conduit may necessitate excessive calculation. Because of these complexities either a digital or an analog computer is then required both to reduce the calculation time and to effectively institute the applicable numerical techniques as is illustrated by Auld and Ritter (2).

A fluid which exhibits a marked variation in rheological behavior, concurrent with the duration of flow, constitutes an even more complex system. In the case of thixotropy, the fluid experiences a breakdown in structure so that pressure head requirements decrease with time while the volumetric flow rate builds up to the designed value (3,4,5). It may take days, however, to attain a suitable flow rate. Therefore, the

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criterion of such design is to accrue an acceptable flow in as short a time as possible through a change in pipe diameter and pump characteristics.

Once again, the representation of rheological properties poses a problem. While the mechanisms of thixotropy have been investigated(6 - 10), the proposed constitutive equations cannot be applied to the prediction of flow phenomena in pipes. This results from either the inappropriate choice of parameters or the lengthy computer calculations that would be associated with the retrieval of the necessary information. Therefore, it is proposed that the segment of data made up of shear stress decay curves are sufficiently accurate.

Previous design attempts(3,11,12) have yielded only qualitative, or at best semi-quantitative, predictions of the flow behavior. With the aid of simplifying assumptions, this thesis presents a rigorous treatment of thixotropy in pipeline flow.

LITERATURE SURVEY

1. Introduction to Rheology

Rheology, "the science of deformation and flow"(1), involves study of movement of all forms of matter. A mathematical representation of flow behavior extends from the concept of a Newtonian fluid, through a spectrum of material, until reaching that of a Hookean - elastic solid. A description of rheological properties within these bounds is approached from either end depending on the nature of the system. Here, the representation of the properties of thixotropy is illustrated by beginning with a Newtonian-type fluid.

Newton's Law of Viscosity is best visualized by considering the flow of an incompressible fluid between two parallel plates(13) as in Figure 1; the bottom plate remains fixed while the top plate moves with a constant velocity V. Under steady-state flow, the velocity between the two plates

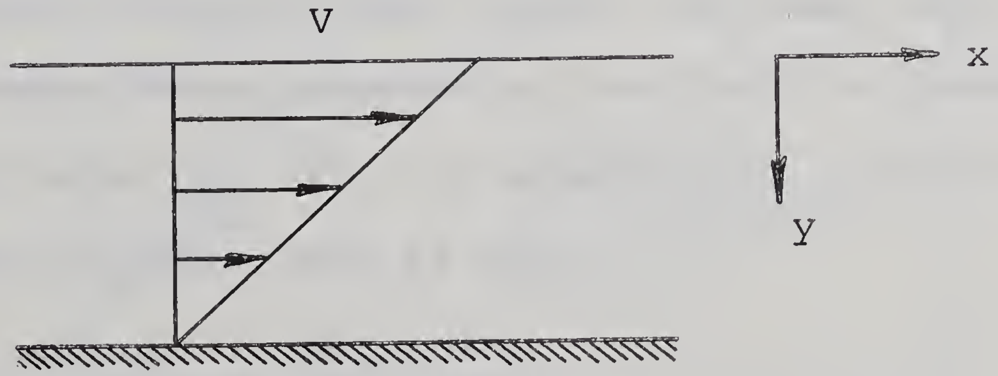

FIGURE 1

is found to be linearly distributed. For a Newtonian fluid, the force per unit area of plate required to maintain a constant velocity is proportional to the ratio of the velocity and the plate separation. This constant of proportionality is defined as Newtonian viscosity. Defining τ, the shear stress, as the reaction force per unit area, then

$$\tau = \frac{\mu}{g_c} \left(- \frac{dv}{dy}\right) \qquad (1)$$

where

τ is the shear stress, lb_f/ft^2

dv/dy is the shear rate, sec^{-1}

μ is the viscosity, $lb_m/ft.sec$

and g_c is a dimensional conversion factor, $lb_m ft/lb_f sec^2$.

A plot of τ versus dv/dy is then a straight line with a slope of μ on arithmetic paper, and a straight line with a slope of unity on logarithmic coordinates. These are pictured in Figures (2a) and (2b) respectively.

Some fluids, known as Bingham plastics, exhibit a linear relationship between shear stress and shear rate but only when the shear stress exerted by the fluid is greater than a limiting value τ_y. If τ is less than τ_y, there is no movement and the shear rate is zero.

$$(\tau - \tau_y) = \frac{\mu'}{g_c} \left(- \frac{dv}{dy}\right) \qquad (2)$$

describes the fluid's flow properties when $\tau \geq \tau_y$.

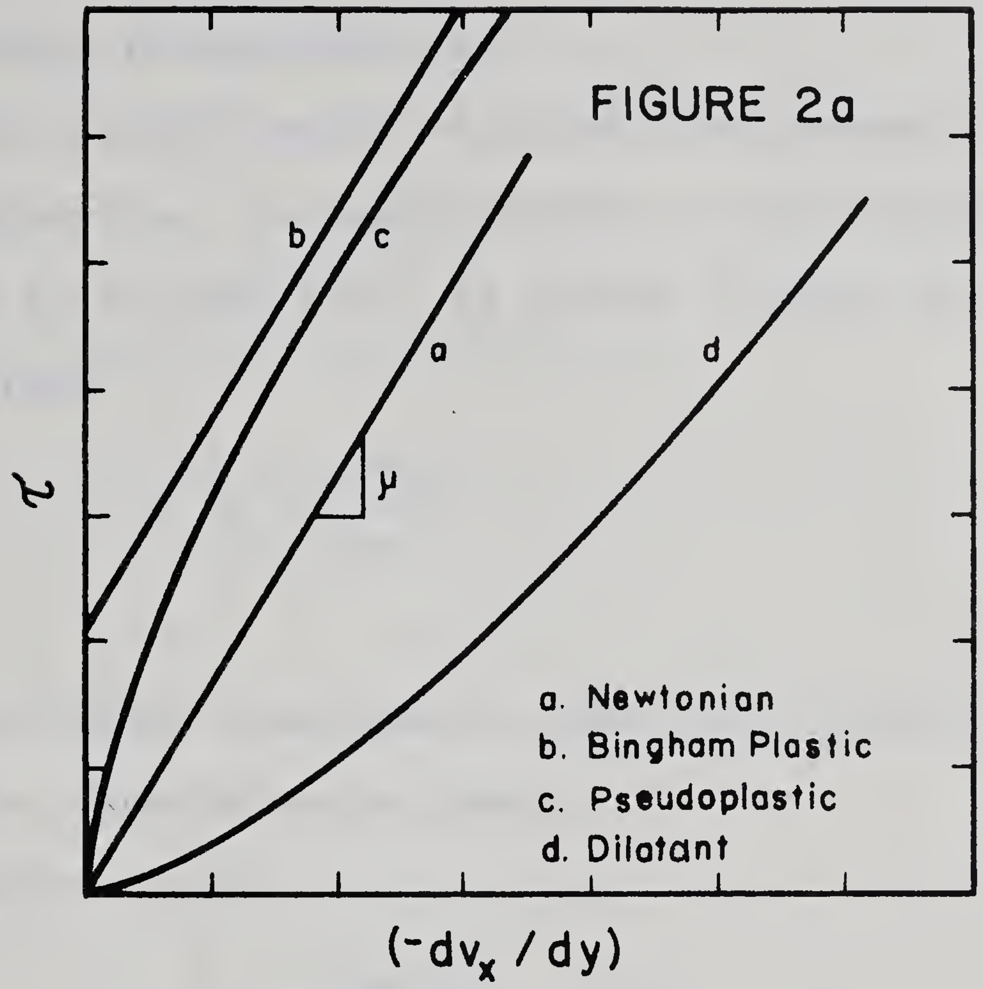

FIGURE 2a

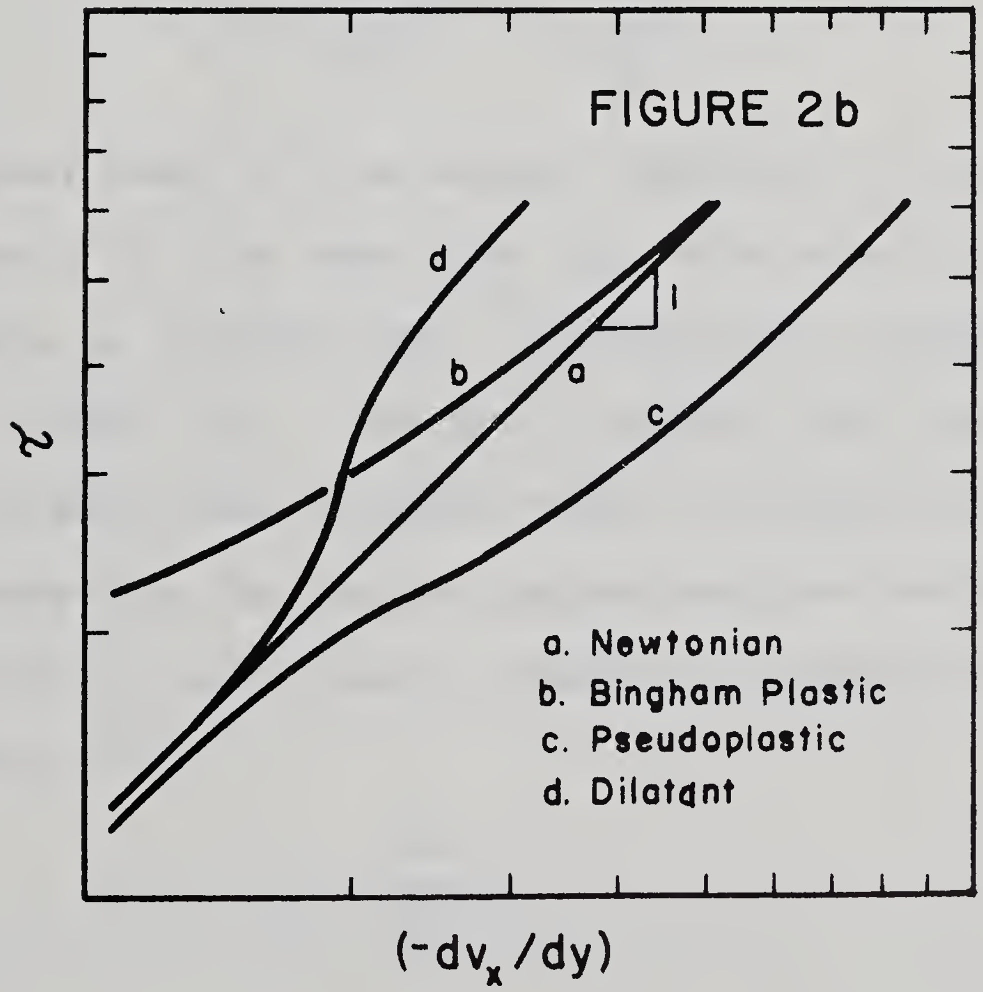

FIGURE 2b

When the limiting value of shear stress is zero, equation (2) becomes equivalent to equation (1).

A third classification of fluid flow properties is known a pseudoplastic. An approximation to this type, set out by Ostwald and by de Waele(14), is called a power-law fluid, which has the form

$$\tau = K\left(-\frac{dv}{dy}\right)^n \qquad (3)$$

where

K is the fluid consistency index, $lb_m/ft(sec)^{2-n}$

and n is the flow behavior index.

Rewriting equation (3) as

$$\tau = K\left(-\frac{dv}{dy}\right)^{n-1}\left(-\frac{dv}{dy}\right)$$

it is easily seen that if n is unity, equation (1) is restated. However, if n is less than one, the shear stress-shear rate curve is concave down, representing a pseudoplastic as in Figure (2a). Setting n greater than one, equation (3) approximates the dilatent fluid of Figure (2).

The foregoing rheological approximations represent almost all fluids in which shear stress is a function of shear rate alone, i.e.

$$\tau = \phi_1\left(-\frac{dv}{dy}\right) \qquad (4)$$

No consideration has been given to shear stress-shear rate dependence on any other variables, namely time and temperature. It has merely been illustrated that a Newtonian fluid acts as a limiting condition of the other two fluid types.

2. Generalized Pressure Drop Calculations

Certain assumptions are generally made before calculating the pressure drop associated with flow in a circular conduit. Without reference to rheological properties, the assumptions are as follows:

1. The flow is at steady state.
2. The fluid is incompressible.
3. The flow is isothermal.
4. Entrance conditions are neglected.
5. The slip at the wall is negligible.

The relationship between pressure drop and shear stress in a pipe is found by evaluating a force balance on a cylindrical element of fluid. The cylindrical surface is positioned about the center-line of flow. The result is given as

$$\left(\frac{\Delta P}{L}\right)_r = \frac{2\tau}{r} \tag{5}$$

where

$(\Delta P/L)_r$ is the pressure drop gradient, $lb_f/ft^2/ft$ of pipe

and τ is the shear stress, lb_f/ft^2 at r, the radius of the cylinder, ft.

By extending the cylinder radius r to that of the pipe R, the shear stress τ becomes the wall shear stress τ_w. Then, the force balance gives,

$$\left(\frac{\Delta p}{L}\right) = \frac{2\tau_w}{R} \qquad (6)$$

If no radial pressure gradient exists, the left hand sides of equations (5) and (6) are equal. This requirement is satisfied when the fluid is incompressible, inelastic and non-thixotropic and when the flow is fully developed. The following relationship is then valid.

$$\frac{\tau}{\tau_w} = \frac{r}{R} \qquad (7)$$

Once shear stress-shear rate data have been made available in the form of an equation of state, i.e.

$$\left(-\frac{dv}{dr}\right) = \phi_2(\tau) \qquad (8)$$

where ϕ_2 is the inverse of function ϕ_1 from equation (4), the velocity profile and the volumetric flow rate can be evaluated. The velocity at any radius in the pipe is obtained by integrating the shear rate along the radius:

$$V_r - V_R = \int_R^r \left(\frac{dv}{dr}\right) dr$$

or

$$V_r = \int_r^R \left(-\frac{dv}{dr}\right) dr \qquad (9)$$

with V_r being the velocity at r, ft/sec

and V_R the velocity at the wall which is zero.

Once the pressure drop has been specified, the shear stress at the wall is given by equation (6), and hence, the shear rate is defined as a function of radius by equations (7) and (8).

The volumetric rate of flow is found by integrating the velocity profile over the area of flow:

$$Q = \iint_A V_r \, dA$$

$$= 2\pi \int_0^R V_r \, r \, dr \qquad (10)$$

where Q is the volumetric flow rate, ft^3/sec.

The average velocity is given by:

$$V_A = \frac{\iint_A V_r dA}{\iint_A dA}$$

$$V_A = \frac{Q}{\pi R^2} \qquad (11)$$

Equations (6) to (11) represent a description of the flow. To this point the equations are independent of fluid properties, with the exception of (7) and (8) which do not incorporate thixotropic behavior.

Since the purpose of these equations is to predict the pressure gradient associated with a given flow rate, it

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should be noted that, in general, an iterative procedure is necessary. This involves selecting values of pressure drop and then comparing the flow rates obtained with the given value until the difference between them falls within a certain tolerable error limit.

A criterion in defining laminar flow has been advanced by Metzner and Reed(16) in the form of a Generalized Reynolds number. It takes the form

$$Re = \frac{D \quad V\rho}{g_c \, \mu_A} \tag{12}$$

where

ρ is the fluid density, lb_m/ft^3,

D is the diameter of the pipe, ft,

V is the average velocity, ft/sec

and μ_A is the apparent viscosity, $lb_f sec/ft^2$.

By manipulation of equations (6) to (11), as per references 14 to 16, the shear stress can be related to an apparent shear rate in the form of a power-law expression:

$$\left(\frac{D \Delta P}{4 \ L}\right) = K' \left(\frac{8V}{D}\right)^{n'} \tag{13}$$

where K' and n' are constants which can be arrived at over a series of flow rates for a particular fluid. Then the apparent viscosity is,

$$\mu_A = K' \left(\frac{8V}{D}\right)^{1-n'} \tag{14}$$

Brodkey(17) has verified that the ratio between the apparent shear stress and the apparent shear rate is also correct:

$$\mu_A = \frac{\left(\frac{D \Delta P}{4L}\right)}{\left(\frac{8V}{D}\right)} \qquad (15)$$

The laminar flow range is then defined in terms of Re and n'. Shaver and Merrill(18) have defined this functionality graphically. They have experimentally found that if n' decreases from unity to 0.53, the Reynolds number can be greater than 3000 before the flow experiences any turbulent fluctuations.

The generalized equations which have been presented are functional in computing the pressure drop of any time-independent rheologically-complex fluid provided that an equation of state is present in an integrable form.

3. A Mathematical Description of Thixotropy

A fluid which exhibits thixotropic properties is one in which shear stress, at constant temperature, is not an unique function of shear rate. Thus, the relationship represented in equation (4) is not applicable. A model describing thixotropy will therefore be developed, in an abbreviated form, as it was proposed by Ritter(7).

Thixotropic fluids can be physically represented by a large network structure of loosely-bonded macromolecules suspended in a Newtonian solvent. Then the stress generated

under shear originates from the resistance offered by the structure as well as from the contribution of the Newtonian solvent. The total shear stress is given by

$$\tau = \tau_s + \tau_\mu \qquad (16)$$

where τ_s is the structural component of shear stress, lb_f/ft^2

τ_μ is the Newtonian component, lb_f/ft^2.

As shearing progresses at a constant rate, the consistency of the fluid decreases, i.e. the shear stress falls as in Figure 3. Physically, this decay results from the simultaneous occurrence of two phenomena; the breakage of the network links and the alignment of the filaments. It has been further contended by Ritter that the rate at which shear stress decreases is dependent only on the duration of shearing and not on the shear rate. By considering the structural decay as a first-order irreversible reaction the following equation for the rate of change of structural stress results:

$$\frac{d\tau_s}{dt} = - k_A \frac{\tau_s}{t} \qquad (17)$$

where k_A is a constant

and t is the duration of shearing, min.

Following a decrease in shear rate, a reconstructive force is encountered. This force, which is the same molecular attraction initially responsible for the structural stress component, is continually creating linkages. Ritter has attributed to the network growth, properties of a second-order

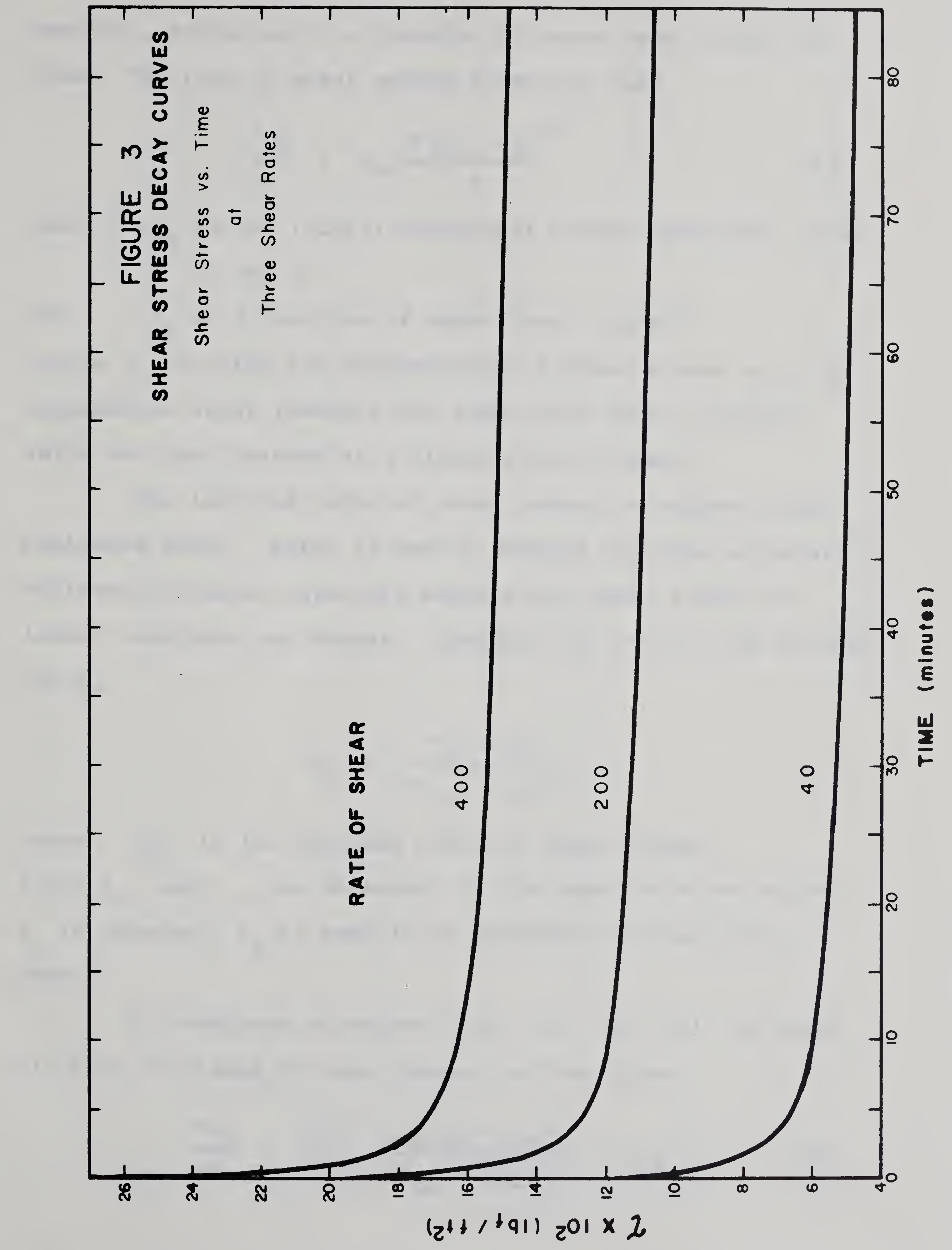

FIGURE 3
SHEAR STRESS DECAY CURVES
Shear Stress vs. Time
at
Three Shear Rates

reaction, rendering it a function of shear rate as well as time. The rate of shear stress growth is then,

$$\frac{d\tau_s}{dt} = k_B \frac{(\tau_{so} - \tau_s)^2}{t} \tag{18}$$

where τ_{so} is the initial structural stress component, given τ_s and t,

and k_B is a function of shear rate, lb_f/ft^2.

Figure 4 indicates the predominance of shear stress build-up encountered after lowering the shear rate once a limiting value had been reached at a higher rate of shear.

The limiting value of shear stress is reached after prolonged shear. Here, it can be assumed that the structural build-up and decay rates are equal since shear stress no longer undergoes any change. Equating (6) and (7) and solving for k_B,

$$k_B = \frac{k_A\,(\tau_{s\infty})}{(\tau_{so} - \tau_{s\infty})^2}$$

where $\tau_{s\infty}$ is the limiting value of shear stress.

Since τ_{so} and $\tau_{s\infty}$ are dependent on the shear rate and since k_A is constant, k_B is seen to be dependent on the rate of shear.

By combining equations (16), (17) and (18) the overall rate of change of shear stress is then given,

$$\frac{d\tau_s}{dt} = \frac{k_A}{t}\left[\frac{\tau_{so}(\tau_{so} - \tau_s)^2}{(\tau_{so} - \tau_{s\infty})^2} - \tau_s\right] \tag{19}$$

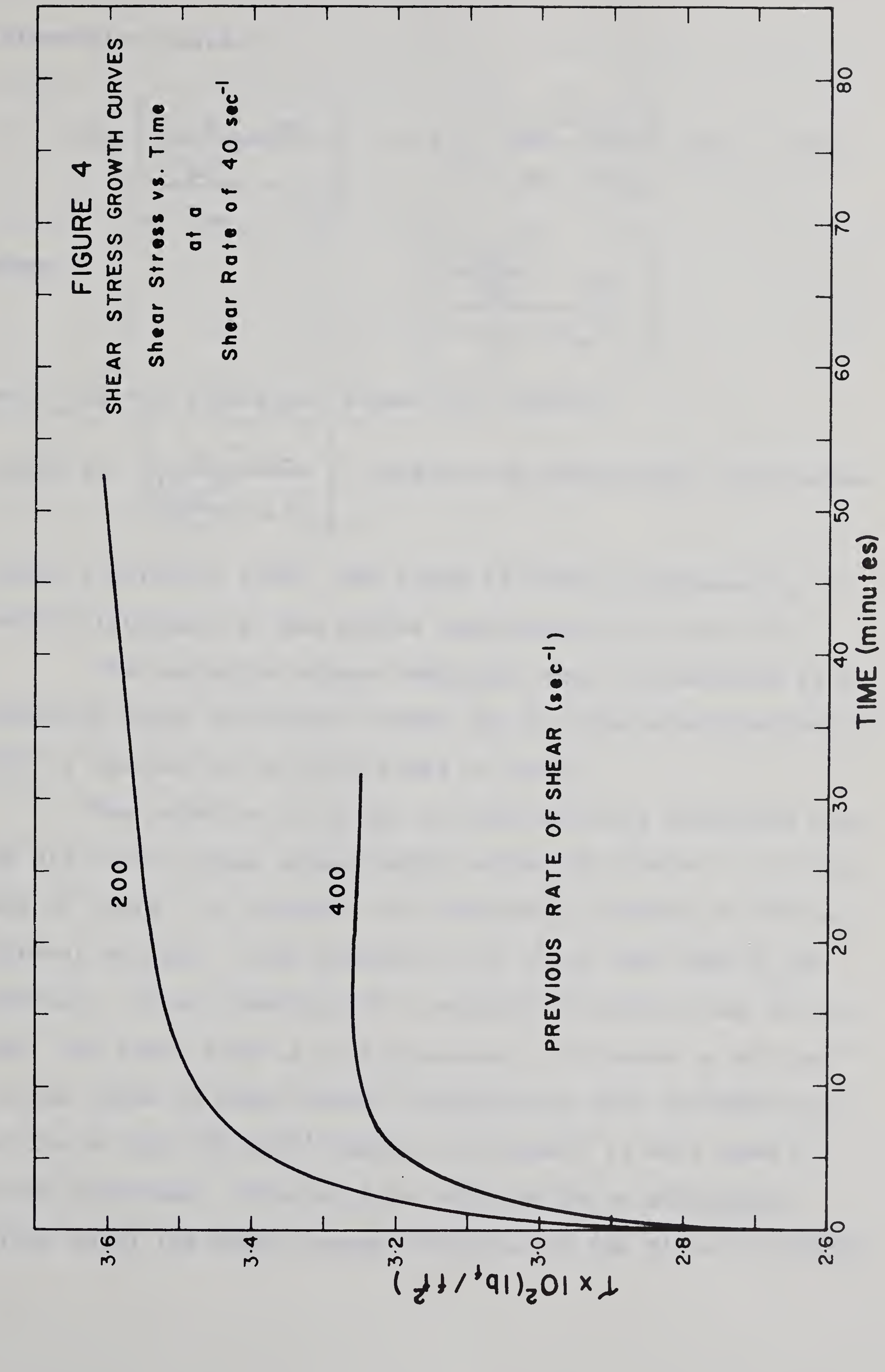

FIGURE 4

SHEAR STRESS GROWTH CURVES

Shear Stress vs. Time at a Shear Rate of 40 sec^{-1}

Integration yields

$$\log \left[\frac{\tau_s - \tau_{s\infty}}{\frac{(\tau_{so})^2}{\tau_{s\infty}} - \tau_s} \right] = -k_A \left[\frac{\tau_{so} + \tau_{s\infty}}{\tau_{so} - \tau_{s\infty}} \right] \log t - \log C \qquad (20)$$

where

$$C = \left[\frac{\frac{(\tau_{so})^2}{\tau_{s\infty}} - \tau_{s1}}{\tau_{s1} - \tau_{s\infty}} \right]$$

and τ_{s1} is the structural stress at 1 minute.

A plot of $\left[\frac{\tau_s - \tau_{s\infty}}{\frac{(\tau_{so})^2}{\tau_{s\infty}} - \tau_s} \right]$ versus t on logarithmic coordinates yields a straight line. The slope is used to evaluate k_A, and the intercept at one minute determines the value of C.

The Newtonian stress component must be evaluated at a condition where structural growth can be considered ineffective. This is carried out at high rates of shear.

The behavior of k_B can be qualitatively explained with the aid of the shear stress decay curves of Figure 3. An element of fluid, for example, is continually sheared at 200 reciprocal seconds. From equation (19) it is seen that k_B is constant. After shearing for a selected duration, say 30 minutes, the shear rate is instantaneously increased to 400 sec^{-1}. The new value of shear stress accompanying this increase will not lie on the 400 sec^{-1} curve, but rather, it will show a slight overshoot. This will be followed by an adjustment period until the shear stress exhibited by the fluid is coinci-

dent with the 400 $\sec^{-1}$ decay curve. The overshoot occurs because the rate of structural growth, and therefore the number of linkages, is greater at the lower shear rate than at the higher rate. The larger number of linkages encountered offer a greater resistance than would be ordinarily anticipated through constant shearing at 400 $\sec^{-1}$, and hence, the higher shear stress. The values of k_B and the structural growth rate at the top of the overshoot, according to equation (18) and (19), are then given by the values of τ_{so} and $\tau_{s\infty}$ corresponding to the shear rate. τ_s will then decrease until its value is consistent with the applied rate of shear. The adjustment periods that were experimentally obtained by Ritter following instantaneous decreases in shear rate are shown in Figure 4.

A similar kinetic treatment of thixotropy was carried out by Denny and Brodkey(10). Their approach differed from Ritter's in that they assumed that the fluid was a mixture of broken and unbroken structure. Ritter, on the other hand, felt that the structure could undergo several cleavages, indicating a series of reactions, before arriving at the completely broken structure. Even though the latter seems more reasonable, both solutions agree quite well with the fluid's rheological behavior.

Although the initial and limiting values of shear stress are uniquely represented at each shear rate, a concept born out by Cheng and Evans(8), the preceding theory does not attempt to describe this functionality. Therefore, utilization

of the theory in the representation of fluid flow is severely handicapped. Its main implementation lies only in describing fundamental properties.

Along with a strong time dependency, the rheological properties of a thixotropic fluid are markedly affected by temperature. Besides increasing the initial and limiting values of shear stress, a decrease in temperature has the effect of making the time dependency more pronounced. In terms of the shear stress decay curves of Figure 3, they move upwards displaying increasing differences between the initial and the limiting stress. It follows that an increase to a sufficiently high temperature results in behavior that is almost Newtonian.

A final characteristic of a thixotropic fluid, with respect to its thermal properties, is illustrated when the fluid, at rest, undergoes a lowering of temperature. During the cooling, a gel forms(3,4,5,12,19). The strength of the gel is similar to the limiting shear stress of a Bingham plastic. The yield, like the consistency behavior of a thixotropic fluid, is temperature dependent such that its value decreases with increasing temperature.

A THEORY OF THE FLOW OF A THIXOTROPIC FLUID

A qualitative understanding of the flow of a thixotropic fluid is derived from the consideration of laminar flow in a circular conduit. The entering fluid as well as that which fills the pipe has no previous shear history and in the following discussion this state will be defined as age zero. A specified flow rate is immediately attained upon the commencement of flow. Since the entrance conditions are neglected, the entering fluid assumes a fully developed profile. Equiradial streamlines are assigned at start-up as in Figure 5a. In order to maintain the incremental flow rates between streamlines at constant values, these streamlines may move radially according to the continuity equation.

As the duration of flow increases after start-up, the consistency of the fluid, because of its aging, decreases. Figure 5b shows the distribution of ages after one minute of flow at four arbitrary locations along the pipe including the entrance. The increment nearest the wall at the three downstream locations indicates a higher average velocity. In order that this incremental flow rate be constant, the streamline must move nearer to the wall. Similarly, adjustments of the other streamline positions occur.

The next time increment, illustrated in Figure 5c, depicts the next possible age and velocity distributions at the four positions in the pipe. Similarly, Figures 5d and 5e

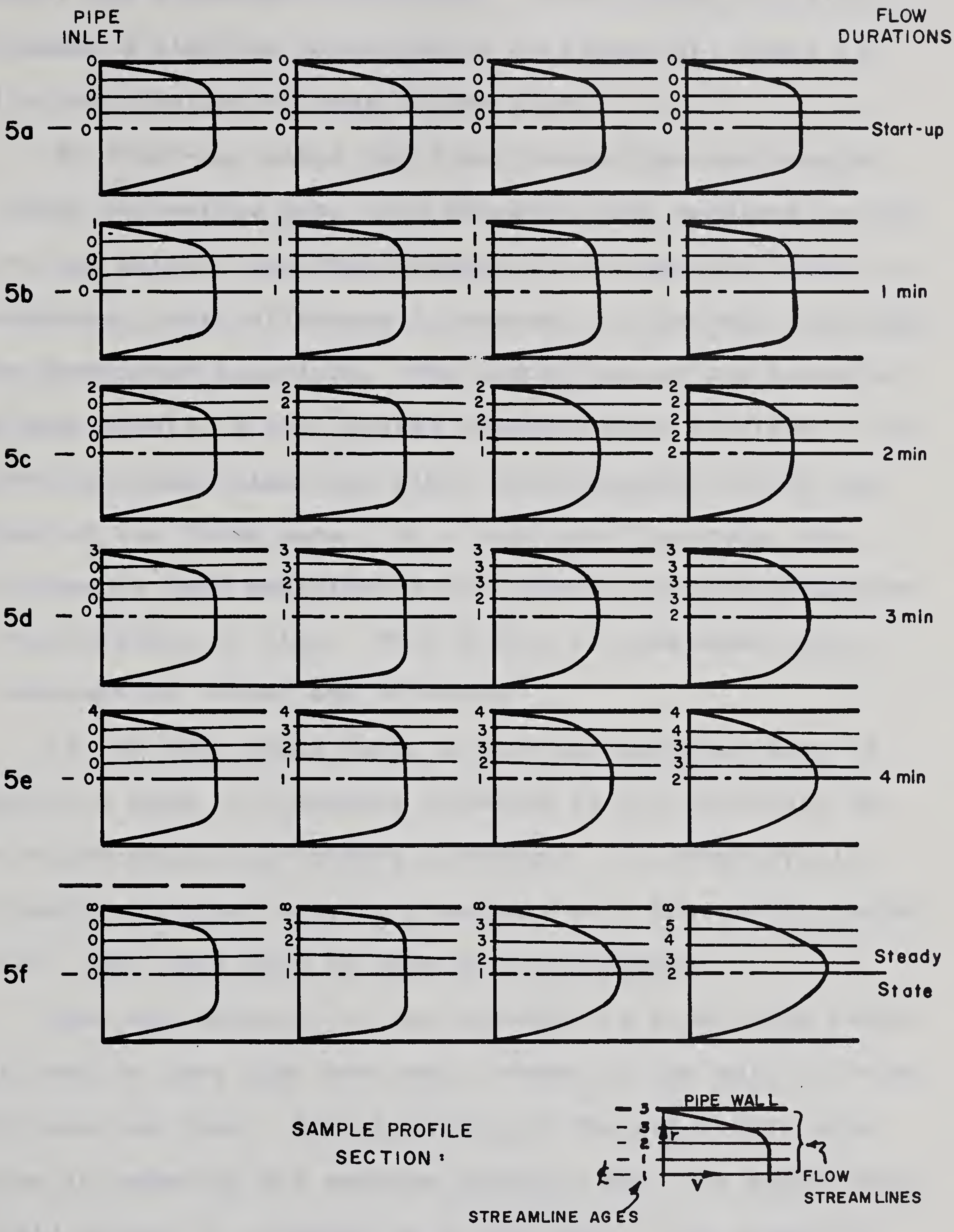

FIGURE 5 VELOCITY PROFILES FOR THIXOTROPIC FLOW

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represent the subsequent conditions. Even though the flow has reached a limiting condition as in Figure 5f, there is still a distribution of ages in the pipe.

At start-up, since the fluid properties are consistent along the entire pipe, the pressure drop gradient is the same at any point. The consistency of the entering fluid in the remaining parts of Figure 5, however, is greater than that at the downstream locations. The properties of the entering fluid then result in the largest pressure drop gradient. The gradient decreases along the pipe, corresponding to the combination of the fluid ages. At a constant flow rate, the total pressure drop exhibited over a length of pipe decreases with the duration of flow. This effect is consistent with that proposed by Govier and Ritter(3).

If, on the other hand, a constant pressure drop is imposed on a pipe, a transient increase in the flow rate results as the fluid consistency decreases. Although Wyllie and Jones(5) obtained varying responses on a laboratory-scaled pipeline, they were able to draw this conclusion.

When the material in the pipeline is a gel, its yield stress must be less than the shear stress at the wall in order to initiate the flow. Deterioration of the gel occurs once the flow is underway and extends radially from the point where the yield stress is exceeded up to the wall. The necessity of a minimum pressure drop to initiate flow is easily substantiated(3,5,6,12). Since the pressure drop gradient and

hence the shear stress decays with time, no further deterioration of the gel can be envisioned. The only portion of the flow which can experience aging is the cross-section of the fluid extending from the edge of the plug-shaped gel to the pipe wall. The concept of a plug is accepted by Sellers(19). Because the plug undergoes no reduction in diameter after start-up, the change in consistency accompanying flow causes the plug to accelerate, thus allowing the streamlines to move away from it.

The shear rate in a thixotropic fluid is a function of time as well as shear stress. The functional relationship represented by equation (8) is extended to include time, i.e.

$$\left(-\frac{dv}{dr}\right) = \phi_3 (\tau, t) \qquad (21)$$

where ϕ_3 is represented by the shear stress decay curves of Figure 3.

The shear stress growth is assumed to be negligible when considering flow in a pipe. This is so for two reasons:

1. The change in shear rate experienced by an element of fluid as it travels down the pipe is small compared to the five and ten fold decreases in shear rate necessary to obtain the data presented in Figure 4. Thus, only minor changes in shear stress will be associated with changes in shear rate, and

2. Restoration to ninety percent of the final value of shear stress occurs about ten times faster than that required for a similar amount of decay.

Therefore, the shear stress data not only control but in fact describe the fluid properties under the continuous shear experienced in pipeline flow. The foregoing discussion is considered as adequate justification for the crucial assumption that the relationship between shear stress and shear rate is a unique function of time.

Equation (6) presents the relationship between pressure drop and shear stress at the wall for steady state flow. Under unsteady-state conditions, this relationship is also a good approximation since its validity can only be affected by radial flow. This is expected to be insignificant when compared with the velocity in the direction of flow. Cheng et al(11) also assumed that the shear stress profile is linear and the shear stress at the wall represents the pressure drop at that point in the pipe. Therefore equation (6) is applicable and similarly equation (5) is assumed to be correct, making the linear relationship of equation (7) represent the flow situation.

For analysis, the pipe is segmented into radial and longitudinal increments. The number of radial increments is chosen so that an increase does not affect the age distribution; the exact nature of the distribution will be mentioned

later. The size of a longitudinal increment is controlled by the error associated with the assumption of linear aging along its length. Because the rheological properties decay in a non-linear manner with duration of flow, these longitudinal increments vary in length.

The transient response of pressure drop at a constant flow rate is approached by selecting various durations of flow in the same manner as that outlined in Figure 5. For example, after five minutes of flow in a pipe which initially contained zero age material and which is fed by zero age fluid, there is a distribution of fluid ages corresponding to the duration of shear. Once the fluid which has been entering for five minutes has been volumetrically accounted for in each increment, only the original fluid that has been continually sheared for five minutes remains. The amount of aging that occurs along each increment complicates the iteration procedure for wall shear stress since the aging is related to an average of the velocities at each end. The velocity profile at the front of the increment is of course to be established in the iteration. Once the pressure drop gradient has been calculated from the wall shear stress at each increment boundary, integration over the pipe length provides the total pressure drop required at each flow duration.

Calculation of the pressure drops at three or four flow rates using common durations of flow facilitates plotting of the pressure drop as a function of flow rate at these flow

durations. However, calculation at a constant flow rate assures that the apparent shear rate is constant and therefore the assumption that the decay curves are valid may appear reasonably accurate. The points which establish a constant flow duration curve are arrived at by using individual average rates of shear. The argument that the growth restoration is both nominal and rapid must once again be relied upon.

A characteristic curve which relates pressure or suction head to a pump's capacity provides a unique value of pressure head for any given flow rate. The response of any flow after start-up can follow only this curve. The characteristic curve is then superimposed on the same coordinates as the constant flow duration curves with allowance being made for pressure losses due to a change in elevation between the pipe entrance and exit. The value of pressure drop for no flow on the pump curve enables calculation of the initial shear stress at the wall. If the fluid is in a gel condition, pumpability of the oil with this pump as well as the plug width of the gel is easily calculated. While the pump's own response is not given, it is assumed that, except for the initial seconds, pressure drop and flow rate will behave in the transient manner indicated by intersections with the constant flow duration curves.

The calculation of the pressure drop is contingent on two main assumptions:

1. The shear stress decay curves represent a unique description of the rheological properties of the fluid, and
2. Shear stress is distributed linearly across the radius of the pipe.

Finally, although it is not correct to ignore the entrance conditions, the resultant error will not affect the total pressure drop over a line of significant length.

PROCEDURE

A computer program was written to calculate, for a constant flow rate, the transient pressure drop response. The development of this program follows.

The pipe was segmented into radial and longitudinal increments. A cross-section of pipe was divided into n radial increments, the ith increment being bounded by r_i and r_{i+1}. Then the velocity at r_{i+1} was deduced from equation (9), vis.

$$V_{i+1} = \int_{r_{i+1}}^{r_i} \left(-\frac{dv}{dr}\right) dr + V_i, \qquad i = 1,2,3 \ldots, n \tag{22}$$

The boundary condition sets the velocity at the wall, V_{n+1}, equal to zero. Using the same nomenclature, the volumetric flow rate within an increment became

$$Q_i = 2\pi \int_{r_i}^{r_{i+1}} V(r)\, r\, dr \tag{23}$$

where V(r) was the velocity distribution with radius and the values of V_i at r_i were points on this profile.

The first task was to establish a method through which shear rate could be obtained for the integration of equation (22). Preparation of the data involved cross-plotting the shear stress decay curves, Figure 3, at constant durations of shear. Then shear rate became the dependent variable, making time and shear stress the independent variables. By assuming that the constant time lines described a series of

pseudoplastic fluids, and by assuming that the shear stress exhibited in the absence of a gel was zero at a zero rate of shear, the fluid properties were extrapolated from Figure 3. The fluid flow properties are shown in Figure 6 on logarithmic coordinates while near the origin they are given on arithmetic coordinates in Figure 7. A value of shear rate was readily defined at a specified quantity of shear stress and time, i.e.,

$$\left(-\frac{dv}{dr}\right) = \phi_3 \ (\tau, t) \qquad (21)$$

To facilitate its use in a computer program, discrete values of data were obtained from these cross-plots, and a Lagrangian Interpolation polynomial(20) (Appendix 1) was employed to provide a value of shear rate at a particular shear stress and flow duration. The interpolation polynomial proved advantageous for a number of reasons.

1. The polynomial did not alter data points, but joined them with a series of curves, or more specifically, it placed a surface between the points. An attempt to obtain a polynomial representation of the complete surface was unsatisfactory because of the inaccuracy of the approximation (based on both least-square and Chebyshev criteria with respect to the data) and because of undesirable curvatures that were superimposed.

2. The interpolation polynomial fitted only a section of the surface as required (Appendix 2) permitting a more accurate representation of rheological properties through

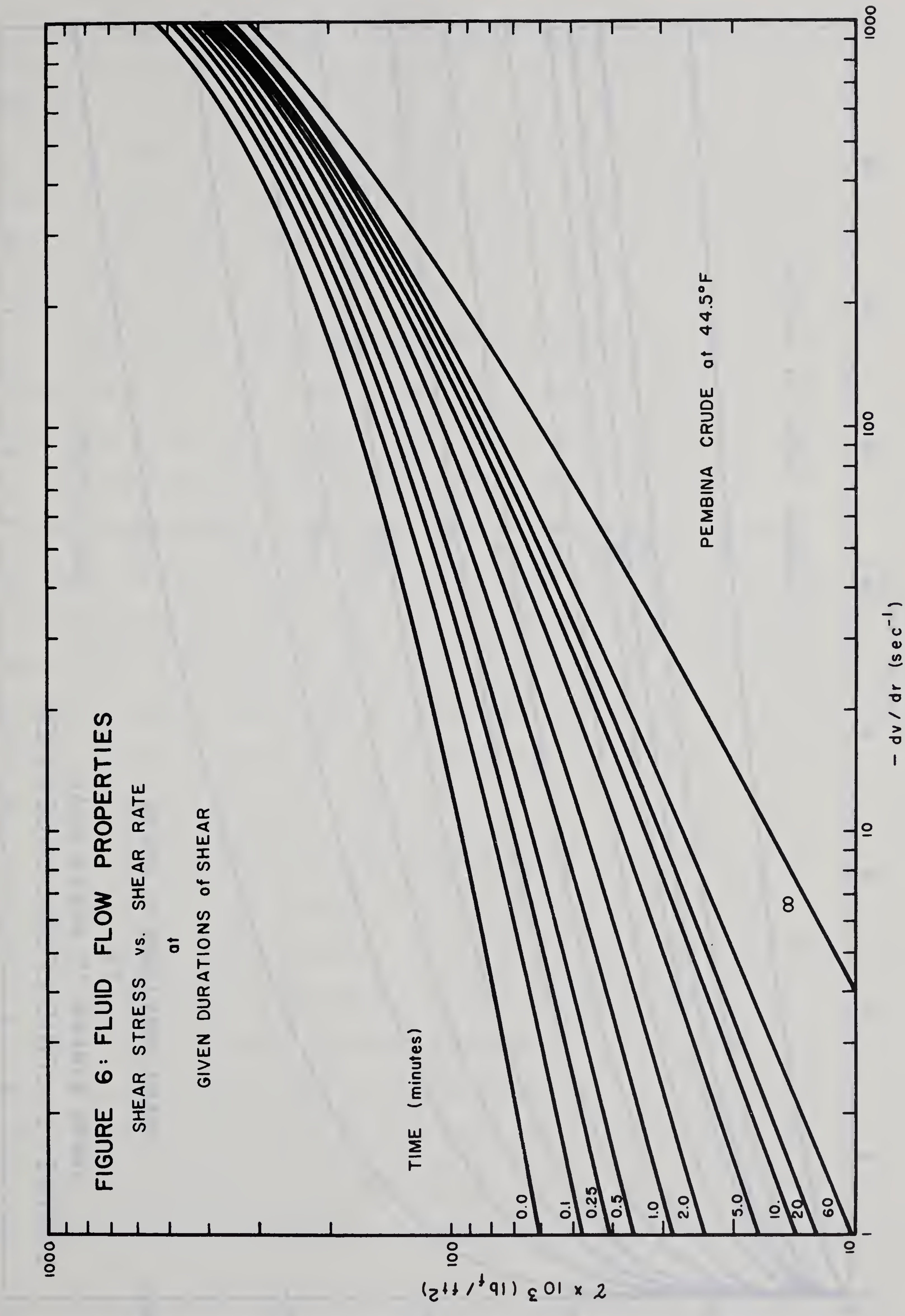


FIGURE 6: FLUID FLOW PROPERTIES

SHEAR STRESS vs. SHEAR RATE

at

GIVEN DURATIONS of SHEAR

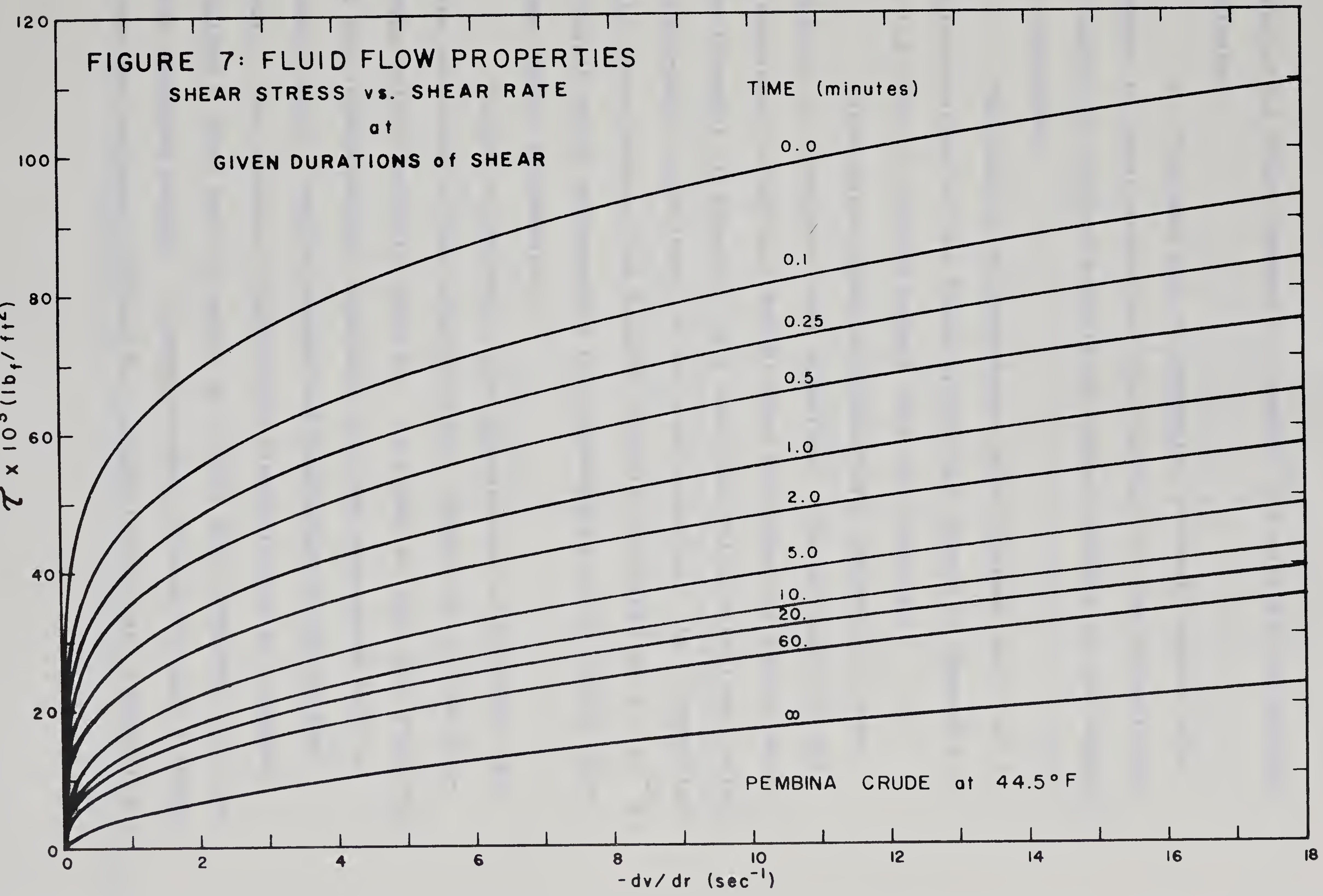


FIGURE 7: FLUID FLOW PROPERTIES

SHEAR STRESS vs. SHEAR RATE
at
GIVEN DURATIONS of SHEAR

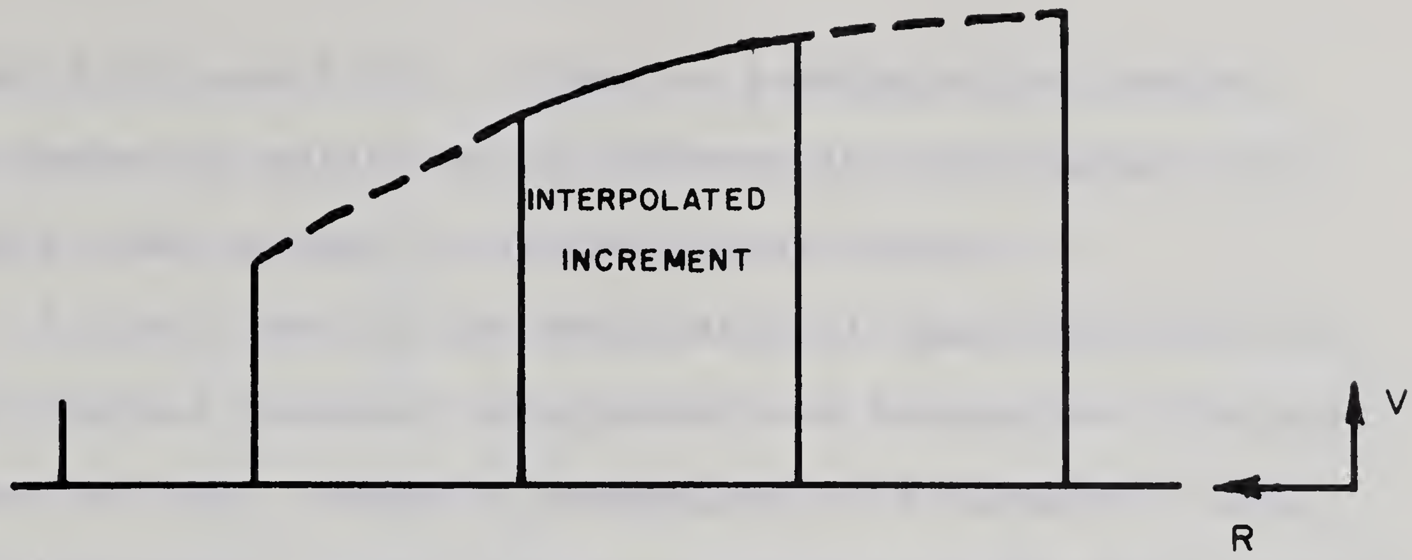
data points where necessary, leaving the rest of the surface unaltered.

3. The data were by necessity unevenly spaced with respect to shear stress and time because of the accumulation of points at regions exhibiting marked changes in the degree of curvature.

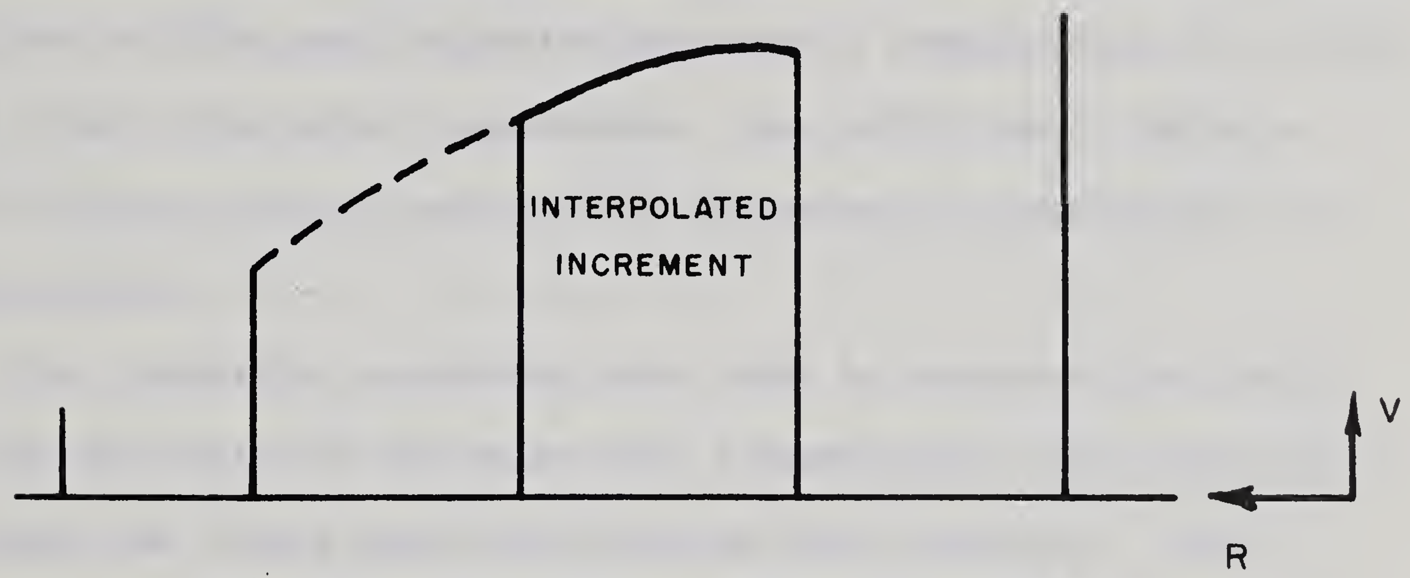
The data which were taken from Figures 6 and 7 as a representation of the fluid properties appear in Appendix 4 in the form of printed output from the computer.

Three-point Gaussian quadrature (Appendix 1) was utilized to integrate both equations. The accuracy of the integration scheme was established by comparing the value of the integral in equation (22) with the value calculated using a five-point quadrature on the same equation. At a specified wall shear stress, the maximum velocity differed by $6 \times 10^{-5}\%$, a result which represented the accumulated error across sixteen radial increments.

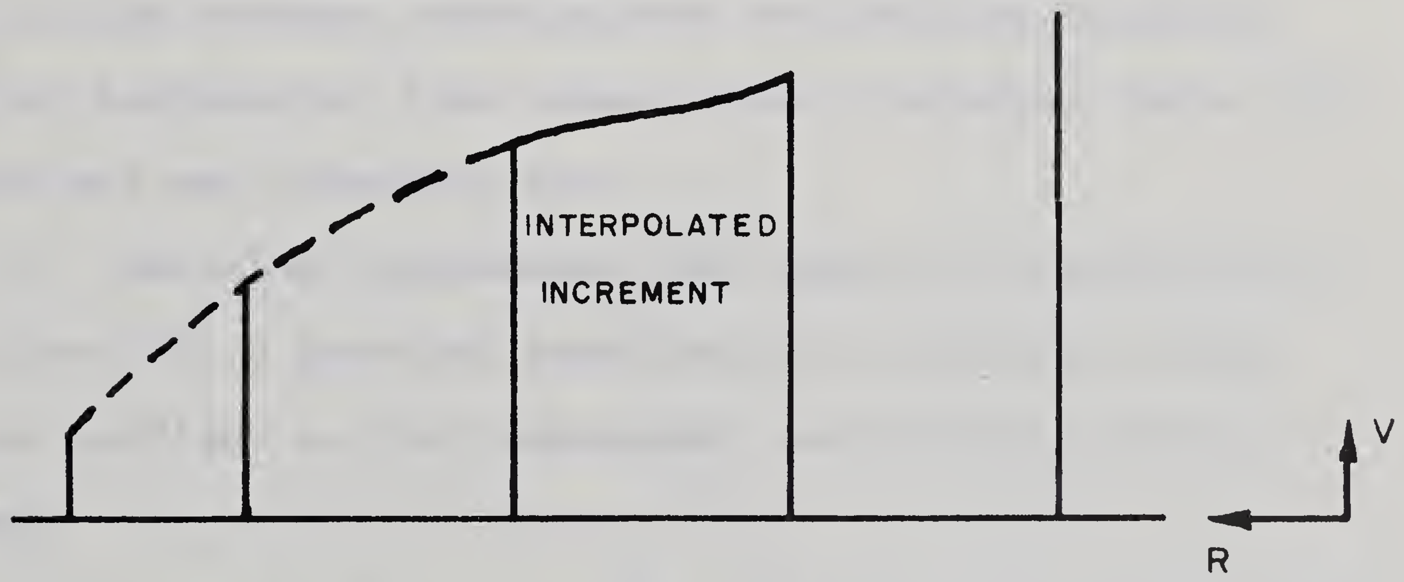
Values of velocity, for integration in equation (22) were extracted by the interpolation, Figure 8a, of the discrete valued velocity profile. In order to test the accuracy of the interpolation, equation (23) was integrated with a Newton-Cotes 17-point closed end quadrature on equispaced radii. The combined integration-interpolation as proposed yielded a flow rate in error by 0.035% when compared with the more accurate method. A second-order, Figure 8b, and a third-order end oriented, Figure 8c, interpolation were respectively



a) THIRD-ORDER INTERPOLATION



b) SECOND-ORDER INTERPOLATION



c) THIRD-ORDER END ORIENTED INTERPOLATION

FIGURE 8 VELOCITY INTERPOLATION SCHEMES

in error 0.11% and 0.20%. Since an interpolation across a larger number of points would increase the calculation time, the third-order scheme of Figure 8a was chosen.

A final test of the computational speed and accuracy of the combined Gaussian integration and Lagrangian interpolation was obtained through a comparison with Simpson's three-point integration. Given the shear stress at the wall, a flow rate error of 10% was indicated through a comparison with that given by the five-point quadrature. An additional computer time of 10% over that used by the three-point quadrature resulted as well.

An iterative procedure was used to compute the shear stress at the wall of the pipe for a particular flow rate provided that the fluid age distribution was constant. This section of the program, usually used at the pipe entrance, arrived at incremental flow rates using a selected radial distribution and was necessary for:

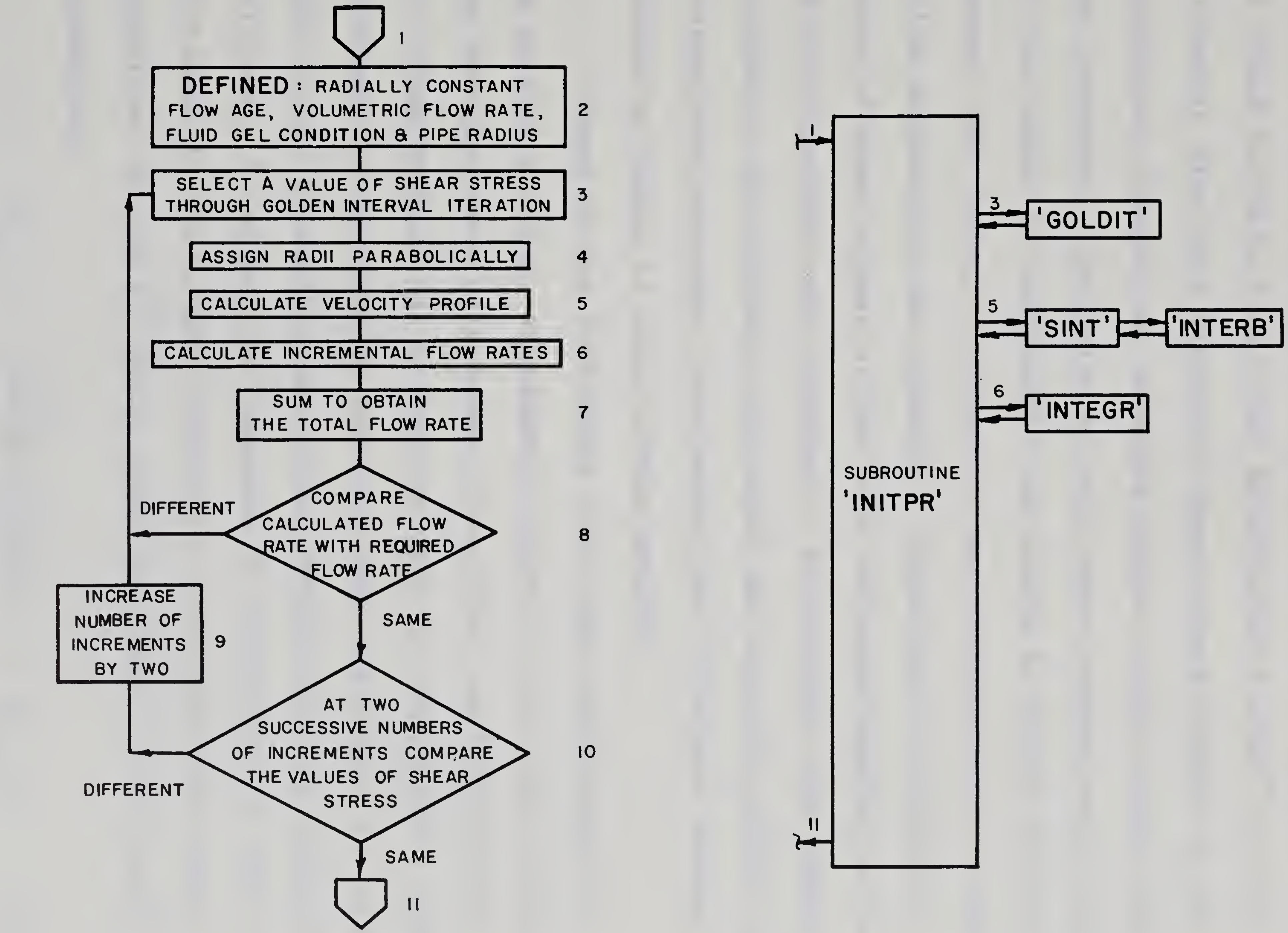
1. defining incremental flow rates at the beginning of the pipe with a constant entering age, assuming a fully-developed profile, so that subsequent calculations could be performed,

2. establishing the radius of a plug at a prescribed flow rate if a gel existed in the fluid (calculated a constant age zero), and

3. calculating the shear stress when a plug existed for some given duration of flow.

The procedure through which flow at the pipe entrance was evaluated also enabled selection of the number of radial increments. This selection was based on the change in wall shear stress obtained at different numbers of increments. Figure 9 presents a schematic representation of the computational procedure for this portion of the program. On the left is the general procedure whereas its deployment through the use of subroutines or subprograms appears on the right. The subroutines, as written in Fortran IV, appear in Appendix 3.

Golden interval iteration(22) (Appendix 1) embodied in subroutine 'GOLDIT' selected trial values of shear stress. Use of this procedure is necessary when the function does not lend itself to a more conventional convergence technique if the function is poorly behaved and convergence is impossible through a more conventional method. Since the incremental flow rates defined the mass balance within increments, it was required that they be defined accurately. Radial streamline positions were then assigned parabolically so that increment widths decreased nearer the wall where the shear rate was highest, allowing for a more uniform integration accuracy across the pipe radius. The integration of equation (22) as previously discussed was carried out in two subroutines; 'SINT' performed the integration of shear rates supplied by 'INTERB'. The total flow rate was the sum of the individual flow rates corresponding to the trial value of shear stress. Then a



a) SIMPLIFIED FLOW DIAGRAM

b) SUBROUTINE BLOCK DIAGRAM

FIGURE 9 CALCULATION OF INITIAL FLOW PROFILE

comparison with the required value of flow rate indicated whether or not the above procedure was to be repeated. It was found for this fluid that an error of $1 \times 10^{-4}\%$ in the volumetric flow rate yielded a shear stress correct to six significant figures and accurate values of flow rates within each increment. The value of wall shear stress, while accurate at this number of increments, was liable to change upon an increase. The number of increments was increased by two and the entire calculation was repeated. Comparison of these two values of shear stress at the wall indicated whether or not a further increase was necessary. By enlarging the number of increments, the accuracy with which the velocity profile was interpolated increased, thus making the difference between successive values of shear stress smaller.

Based on the individual flow rates established in the initial profile, subsequent values of wall shear stress down the pipe were calculated. The fluid age distribution at a cross-section was related to that at the previous cross-sectional distribution by assuming that the change in velocity along a flow streamline was linear between the two longitudinal positions. In effect the increase in fluid age was taken to be related to the average velocity, or defining the age on streamline, at the j^{th} point along the pipe and at the m^{th} streamline.

$$T_{m,j} = \frac{2(L_j - L_{j-1})}{(V'_{m,j} + V'_{m,j-1})} + T_{m,j-1} \qquad (24)$$

where T is the age of the fluid, min.

V' is the velocity of the streamline, ft/min.

and L is the distance from the pipe entrance, ft.

In the process of establishing the use of this definition, several types of age distribution were attempted. It was thought at first that an average age representing each flow increment at a cross-section was sufficient. Therefore, the average age in an increment was calculated from the average velocity across the increment by using the incremental flow rate and the radii of the streamline boundaries. However, the value of shear stress that was obtained proved to be highly dependent on the number of radial increments so that the greater the number, the lower the value of shear stress until it approached a limit. Consequently, in order to obtain an answer which was accurate to 0.01%, based on the finally accepted answer, it would have necessitated the use of about 50 increments, making computational time of the program prohibitive. The percent error in shear stress as a function of the number of increments is shown in Figure 10. As the next step, a linear distribution was assumed across each increment based on the streamline ages as calculated from equation (24). The age of the fluid at the pipe wall was defined to be the amount of time which had elapsed since initiation of flow. Resulting values of shear stress again proved to be highly dependent on the number of radial increments.

However, this time, the values of shear stress rose with an increasing number of increments as in Figure 10. It was found that the width, and therefore the linearization of time distribution, in the increment next to the pipe wall also influenced the solution. A convergent answer independent of this width could not be obtained.

It was then realized that the fluid ages had to be distributed non-linearly across each increment following equation (24). In order to do this, the velocity at the quadrature locations necessary in finding the incremental flow rate were used. This assumed that a quadrature location within an increment was in the same relative position (between two streamlines) at two consecutive cross-sections. For this to be true, the velocity profile in an increment would have to maintain a constant shear rate ratio between the two cross-sections. While in fact, this is not true, for closely spaced longitudinal points, the accompanying error is small, as the minor changes in increment widths at two consecutive cross-sections show (Appendix 4). Figure 10 indicates that the value of shear stress is relatively independent of the number of radial increments when this latter method is used in assigning the age distribution. The errors shown in Figure 10 are based on the result of this scheme using 24 increments.

The iterative procedure which established the shear stress at the wall was now complicated by the necessity of

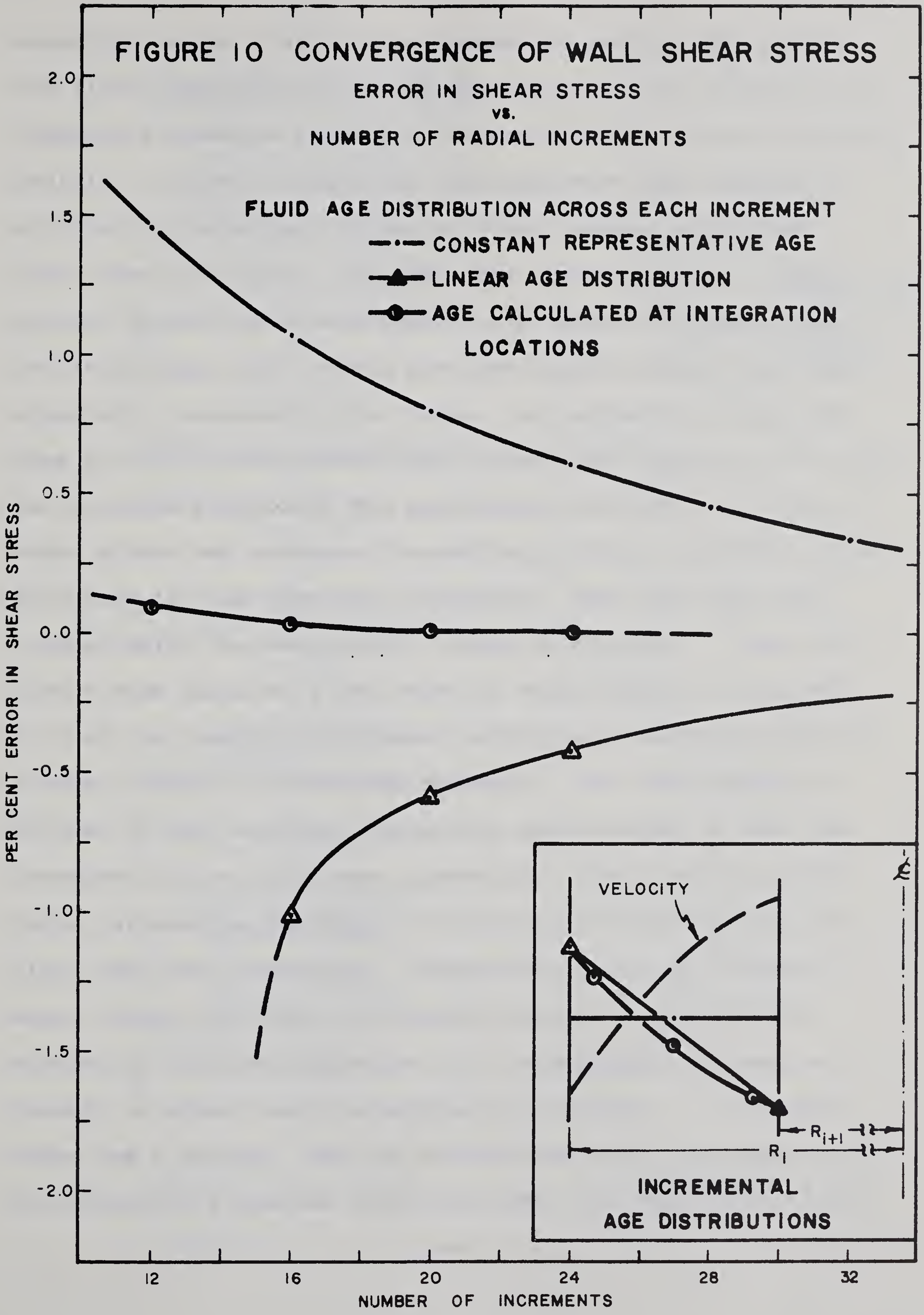
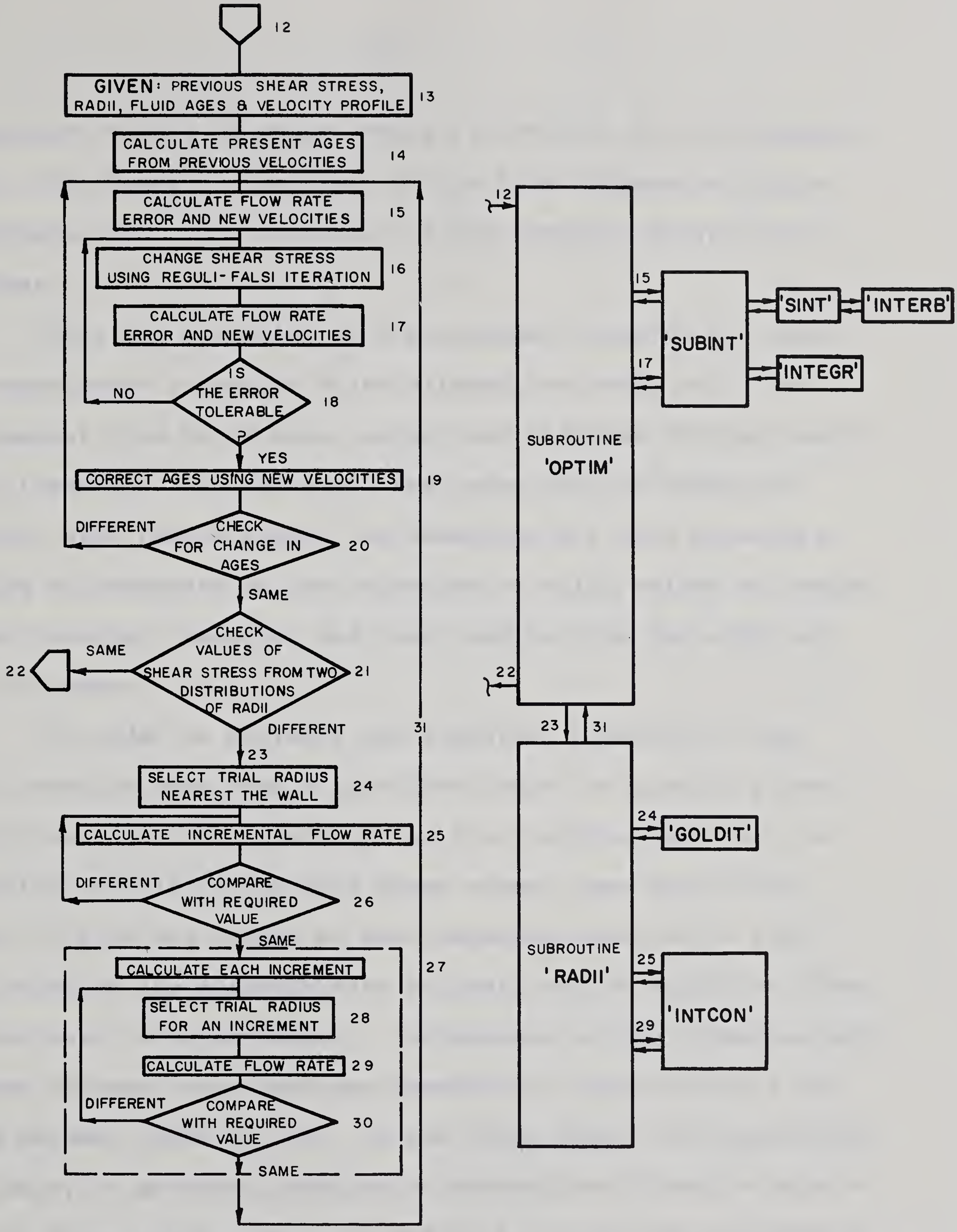


FIGURE 10 CONVERGENCE OF WALL SHEAR STRESS

ERROR IN SHEAR STRESS
VS.
NUMBER OF RADIAL INCREMENTS

obtaining an age distribution across the radius, and since the fluid properties were time dependent, by the necessity of changing streamline spacing to accommodate the altered velocity profile. Figure 11 shows the technique that was employed in arriving at convergent values of shear stress, velocities, fluid ages, and radii. To begin the computation at a cross-section beyond the pipe entrance, the values of shear stress and streamline radii at the previous cross-section were used along with incremental flow rates. An estimate of the fluid ages for this cross-section were found from equation (24) using the previous profile at the quadrature locations. A value of shear stress was computed through Reguli-falsi iteration until the error in flow rate was acceptable. Then the ages were changed using the newly-found values of velocity. These different ages required a new value of shear stress at the wall, so that the iteration for shear stress was continued until no further change in fluid ages occurred. Then the radial positions of the increment boundaries were altered so that the incremental flow rates were corrected. After changing these radial streamline positions, the values of shear stress and fluid ages were corrected. Comparison of the new value of shear stress with that calculated prior to a shifting of streamline position indicated if a convergence had been attained, in which case the profile was complete. If however, there was a change, then the streamlines were again moved and the iteration procedure continued until the comparison of two



a) SIMPLIFIED FLOW DIAGRAM

b) SUBROUTINE BLOCK DIAGRAM

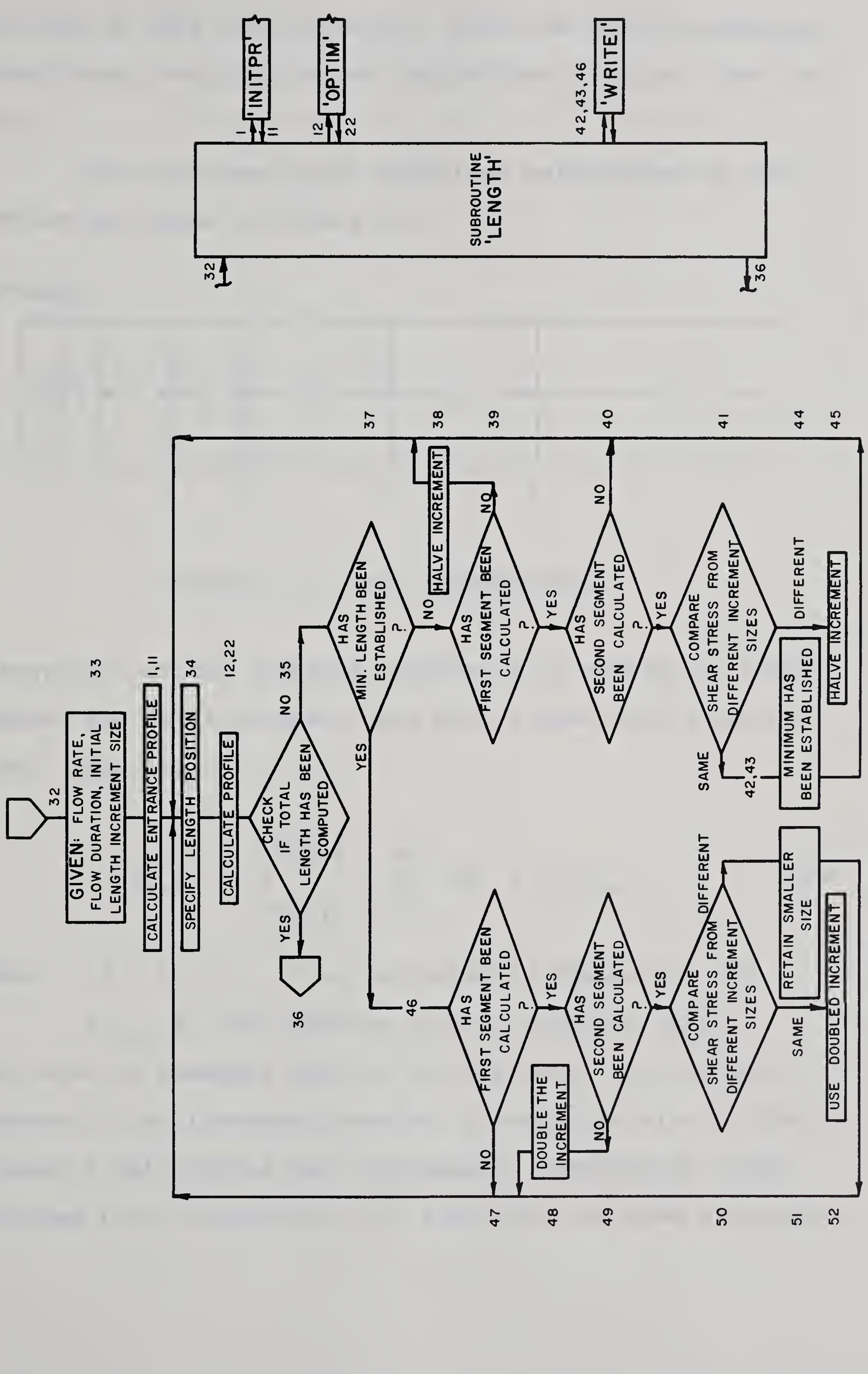
FIGURE 11 GENERAL CALCULATION OF A FLOW PROFILE

consecutive values of shear stress fell within the convergence limit. The boxes to the right of the flow diagram in Figure 11 indicate the interconnection of the computer program subroutines.

With the exception of the increment nearest the wall, the convergence procedure which altered the radii until the incremental flow rates were correct was effected through Reguli-falsi iteration. At the wall, the large rate of change of velocity with radius proved too demanding for this procedure causing a divergence in the selection of trial values of radius. Golden interval iteration was then used to find the width of this increment.

In order to estimate the transient behavior in the total pressure drop over a specified length of pipe at a constant flow rate from "start-up" to the limiting condition, a step-wise calculation of wall shear stress down the entire length of pipe was needed at each selected duration of flow. This required the determination of positions at which the interactions were to be performed. Correctness of the linearizations of ages between cross-sections necessarily restricted the distance between these points. On the other hand, the exponential-type decay in pressure gradient increased the allowable separation of these points, for a specified accuracy, from a minimum at the entrance to a very large separation at the end of the pipe. The criterion which established the acceptable distance over which the age distribution could be assumed to be linear

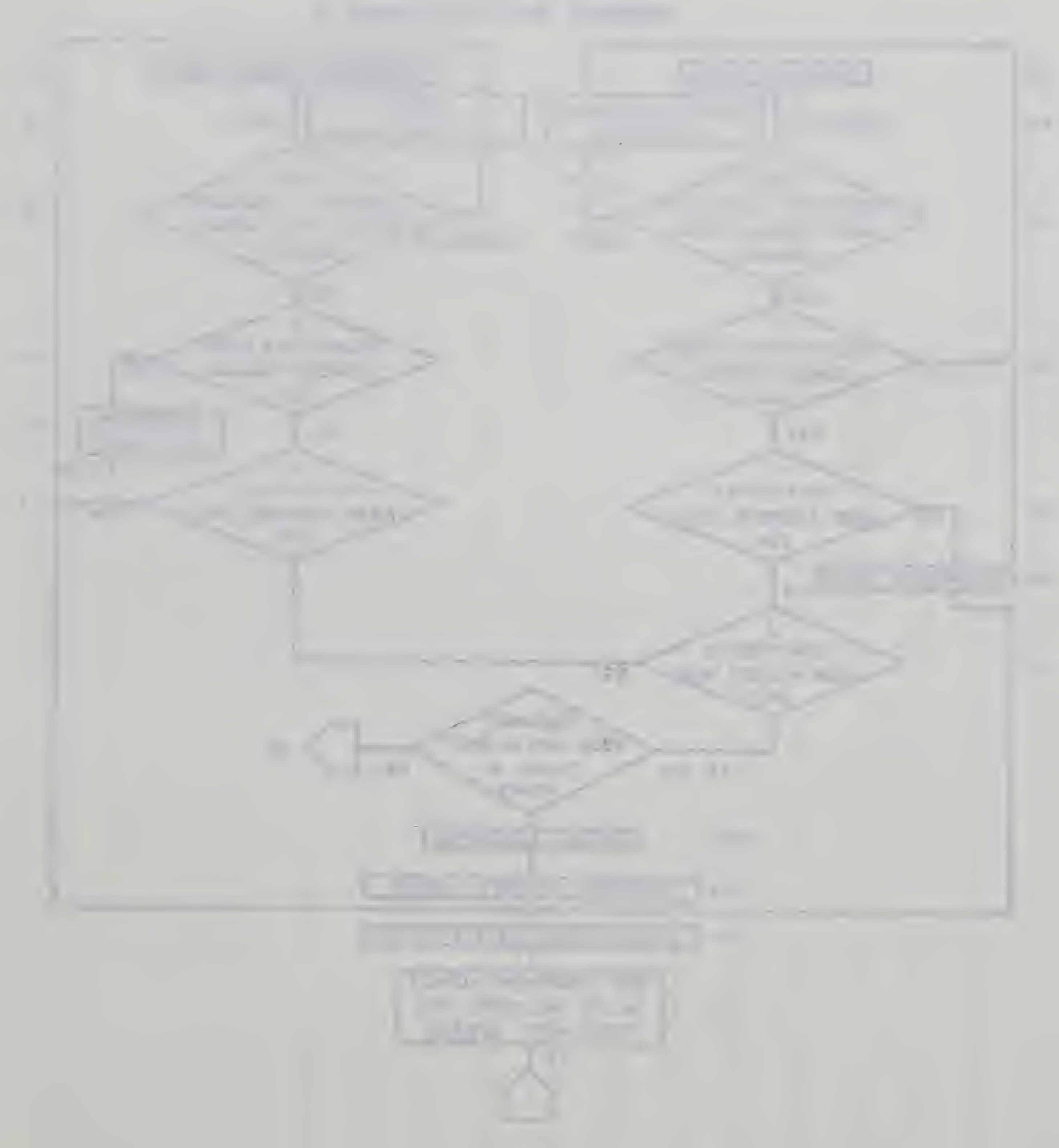
was a comparison of two values of shear stress calculated in the following manner. The shear stress was computed for a cross-section separated from the previous one by a distance ΔL. This distance was then cut in half to give two segments $\Delta L/2$ in length. Computation up to the total length, ΔL, proceeded by obtaining the shear stress at $\Delta L/2$ from the first cross-section and then moving $\Delta L/2$ to obtain the shear stress at the second. The two values of wall shear stress at ΔL from the first profile were then compared. The selection of distances between cross-sections was carried out in subroutine 'LENGTH', the flow diagram for which is shown in Figure 12. After calculation of an initial profile of constant entering age, the shear stress was found at a preselected position. The increment length was halved and the shear stress was found in two steps up to the same previous cross-section. A comparison of shear stresses established whether or not the smaller increment size was sufficiently small or whether it was to be further halved. A minimum increment size, based on the convergence limit established for the program, was found. This step size was used until the comparison of shear stress taken over two increments allowed a doubling in increment size. Thus, a 100 mile pipe was described using 33 positions after starting with a length of 10 feet. Establishment of positions was done for an infinite duration of flow (assumed to be 4000 minutes) since the largest change in pressure gradient



a) SIMPLIFIED FLOW DIAGRAM

b) SUBROUTINE BLOCK DIAGRAM

FIGURE 12 SELECTION OF LENGTH INCREMENTS



occurred at this flow duration. With the length positions established, computation was carried out at other flow durations.

The cross-sectional positions established in this problem are shown in Figure 13:

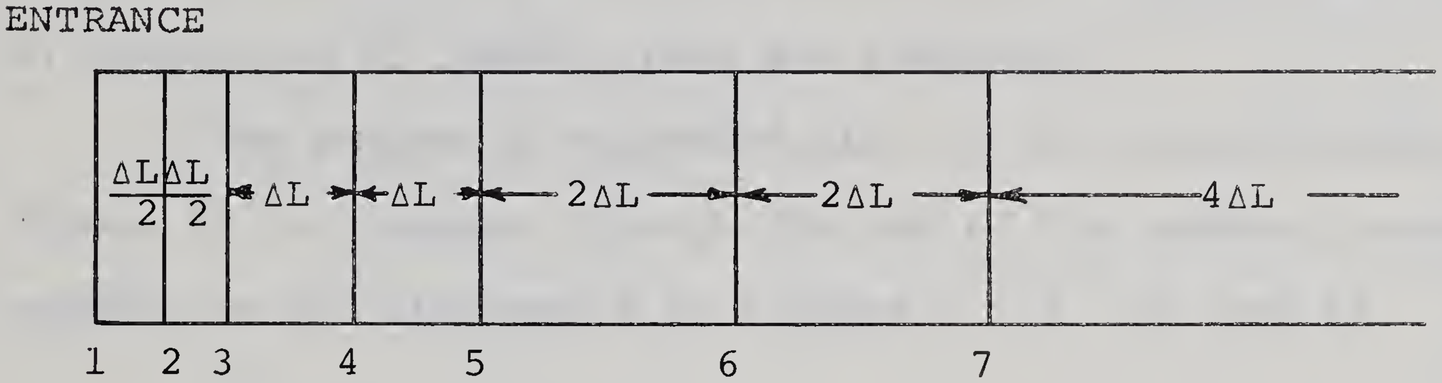


FIGURE 13: PIPE SEGMENTATION

Integration of the pressure gradient with respect to length yielded the total pressure drop over a specified length of line. That is,

$$P_{2j+1} = \int_{L_{2j-1}}^{L_{2j+1}} \frac{dP}{dL}\, dL + P_{2j-1} \tag{25}$$

where (j = 1,2, ...) as indicated in Figure 13, and

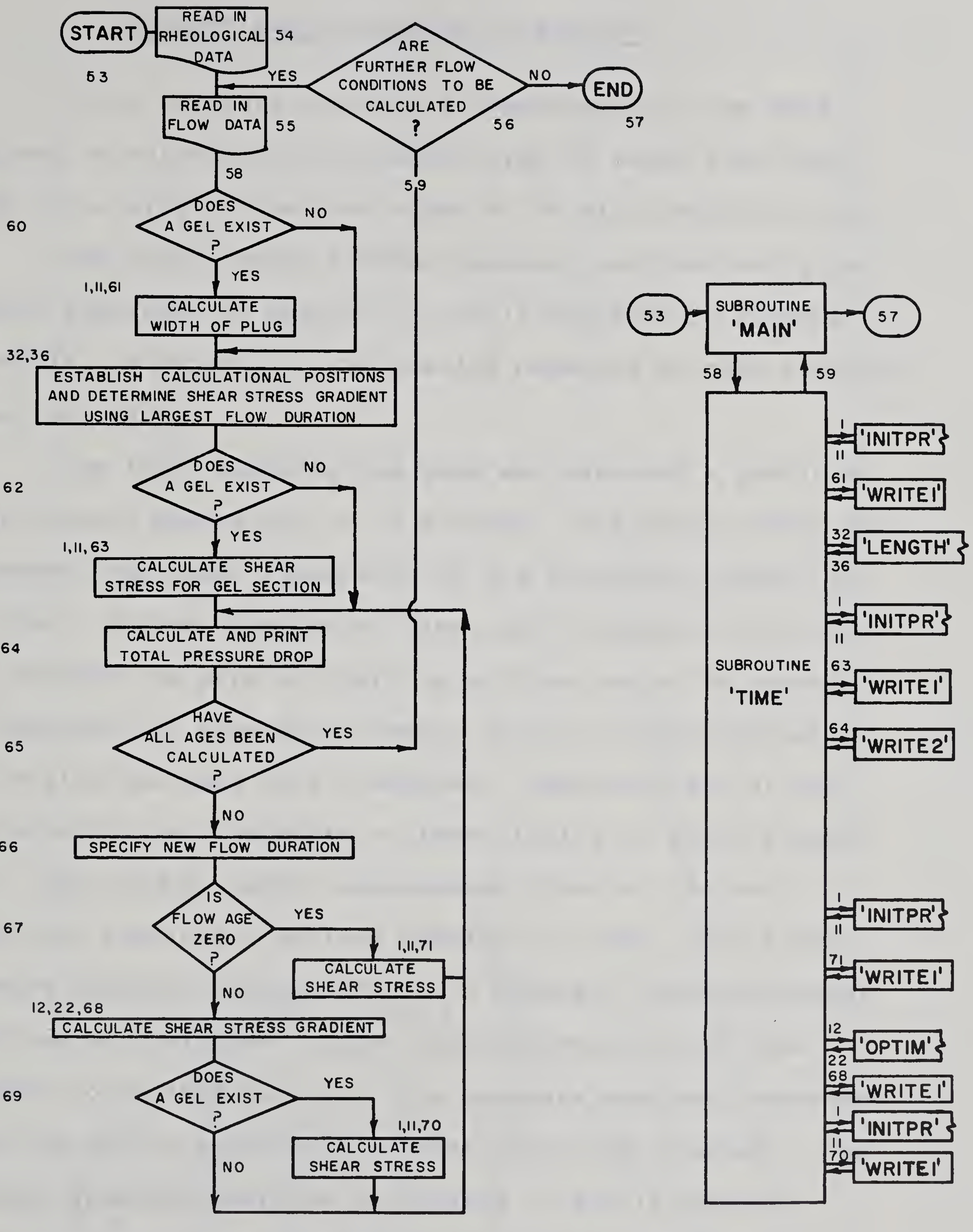
P_{2j+1} is the pressure drop at position 2j+1;

The value of pressure drop at the entrance, P_1, was zero. Because of the increment spacing, integration with a 3-point Simpson's Rule proved very convenient. Subroutine 'TIME' effected this calculation. In addition, the same subroutine

was used to compute the pressure gradient and the accumulated pressure drop at other durations of flow.

A generalized Reynolds number was calculated at each cross-section by way of equation (12) using the apparent viscosity defined by equation (15). While a Reynolds number has not been generalized for fluids with a thixotropic rheology, an indication of laminar flow was necessary.

The schematic representation of the entire program in Figure 14 is pictured through the use of the numbers corresponding to the statements in Figures 9, 11, 12, and 14.



a) SIMPLIFIED FLOW DIAGRAM

b) SUBROUTINE BLOCK DIAGRAM

FIGURE 14 OVERALL COMPUTATIONAL PROCEDURE

RESULTS AND DISCUSSION OF RESULTS

Fifty to sixty minutes of computational time were required to calculate the pressure drop at seven flow durations for a single flow rate along a 100 mile length of pipe.

The relationship between pressure gradient and pipe length, tabulated in Appendix 5 and illustrated in Figures 15 and 16, is typical of the results obtained by this computational procedure.

The fluid entering the pipe was assigned a previous shear history equivalent to 10 minutes. Originally there was unsheared (age zero) fluid with no gel structure present in the pipe. At one duration of flow, say 2 minutes, the fluid that entered the pipe at start-up with an age of 10 minutes had undergone 12 minutes of shear, but the fluid originally in the pipe had aged only 2 minutes. Resulting was an age discontinuity and therefore a discontinuity in fluid properties. Age two min. fluid, encountered first at the wall, caused the previously falling gradient to rise. The final pressure gradient corresponded to a constant cross-sectional fluid age of 2 minutes. After infinite duration of flow (assumed to be 4000 minutes), the pressure gradient decreased along the entire pipe until a lower limit was attained. The pressure gradient profiles in Figures 15 and 16 apply to fluid entering with a previous shear history equivalent to 10 minutes. In Figure 17 the entering material has no pre-

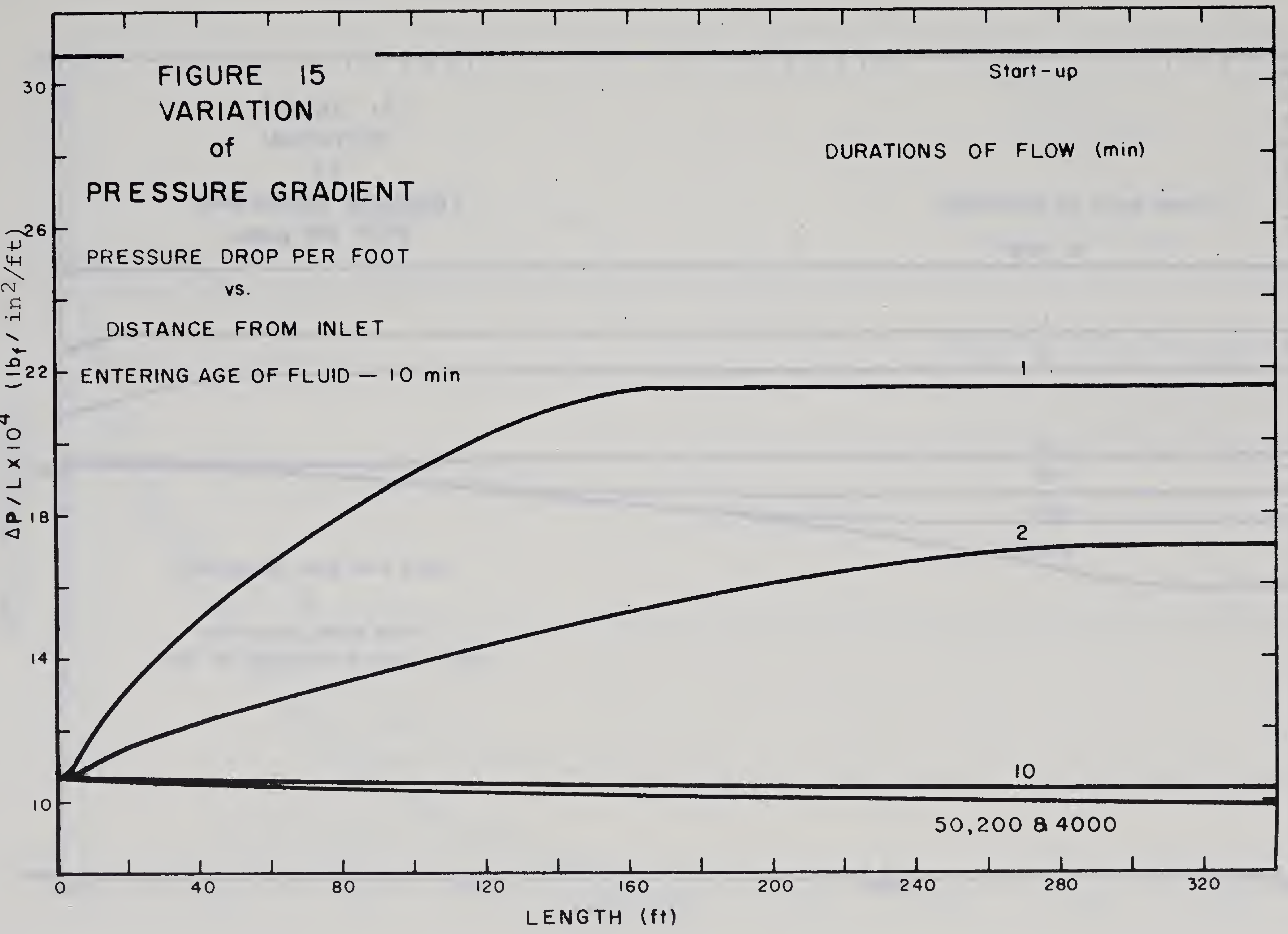


FIGURE 15
VARIATION
of
PRESSURE GRADIENT

PRESSURE DROP PER FOOT
vs.
DISTANCE FROM INLET
ENTERING AGE OF FLUID — 10 min

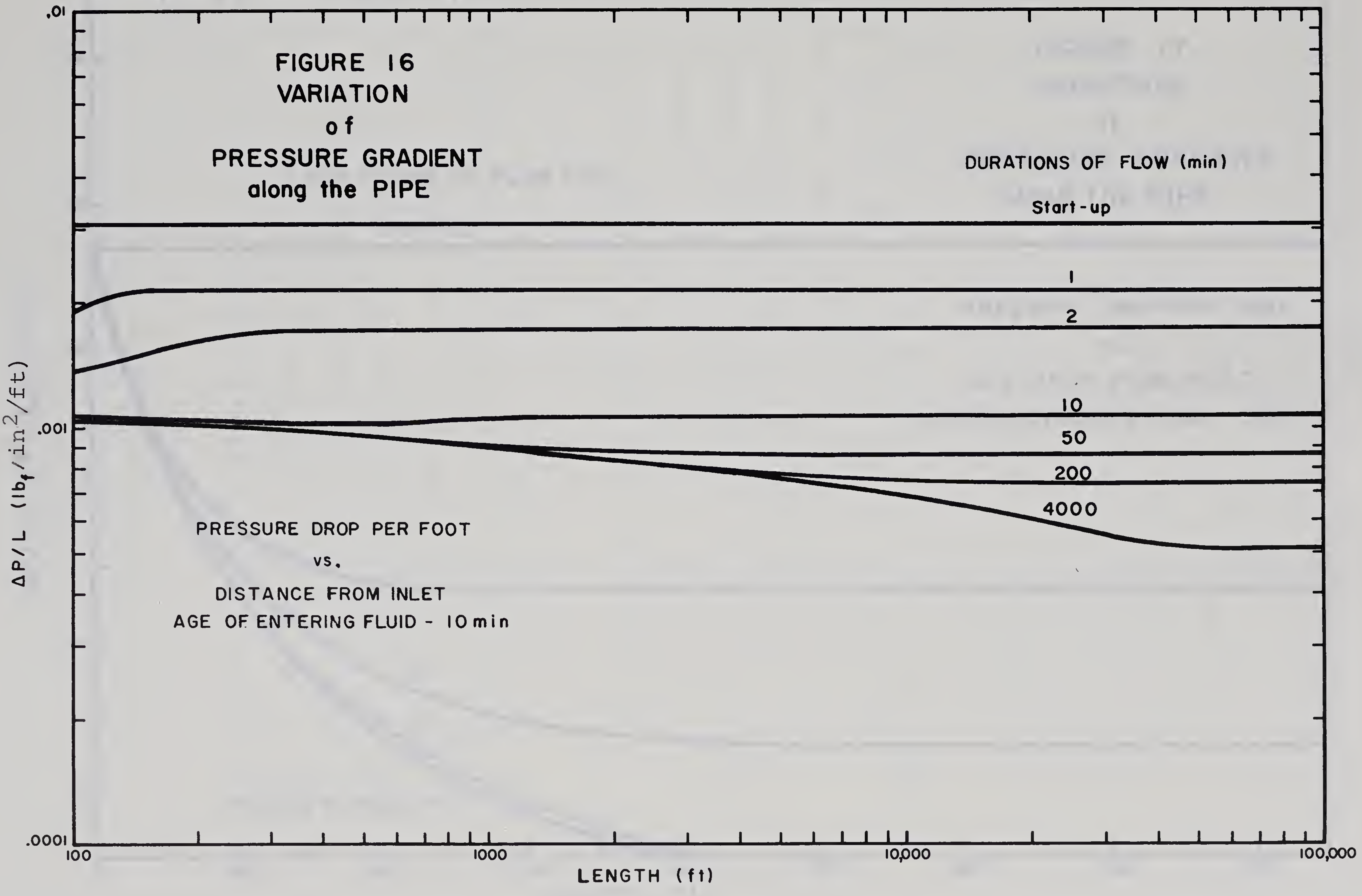


FIGURE 16
VARIATION
of
PRESSURE GRADIENT
along the PIPE

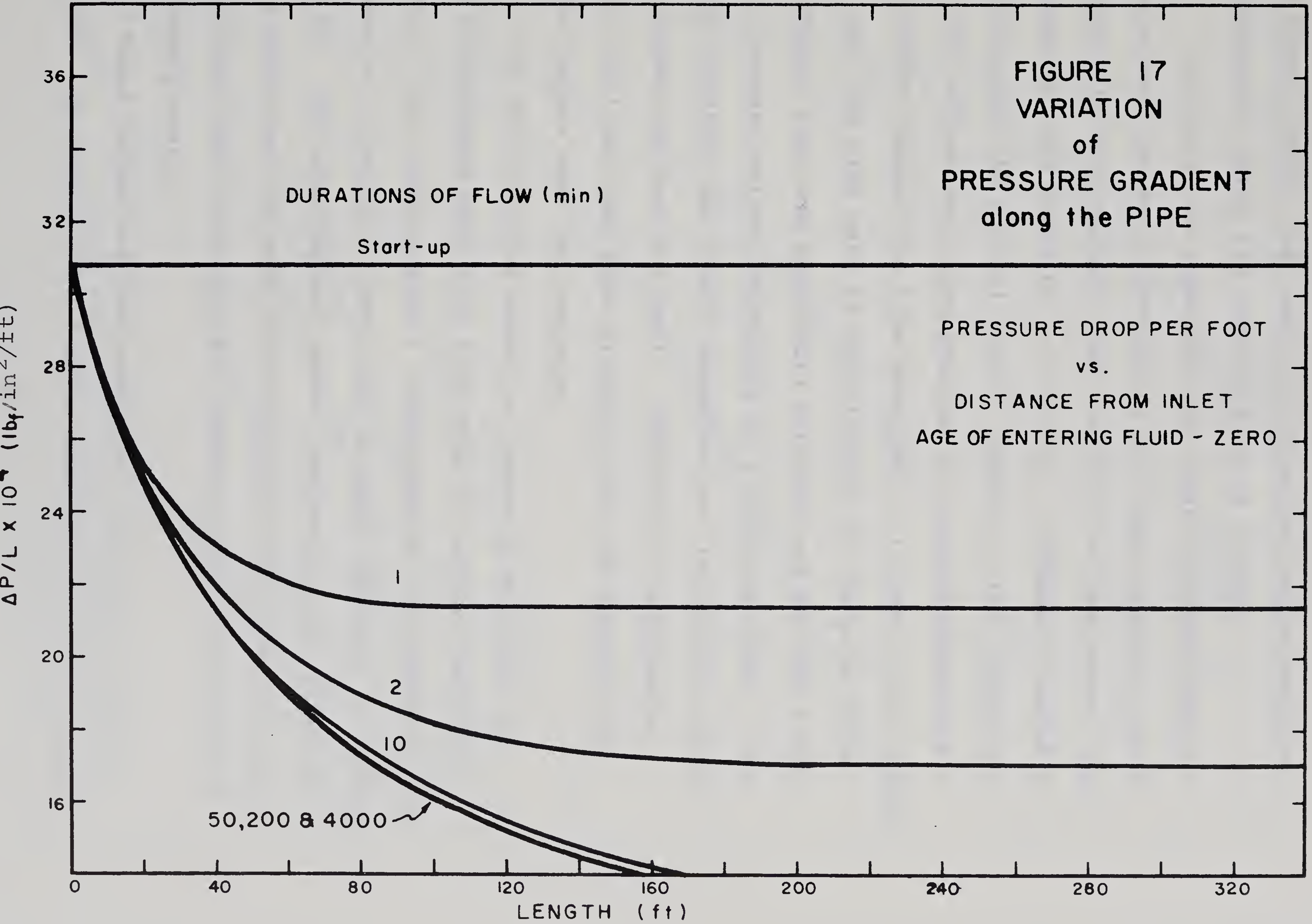


FIGURE 17
VARIATION
of
PRESSURE GRADIENT
along the PIPE

PRESSURE DROP PER FOOT
vs.
DISTANCE FROM INLET
AGE OF ENTERING FLUID - ZERO

vious shear history (age zero), a situation which would be encountered by using the suction side of a pump.

Initially, as expected, the fluid occupying the increments near the wall, because of its lower velocity, aged substantially more rapidly than the fluid at the center line. Consequently, the velocity in the outer increments tended to increase above its initial value. However, with increasing time, this effect was eliminated as the overall ages became more uniform (nearer the flow duration). In fact, at a fixed point near the pipe wall in the vicinity of the pipe inlet, the tendency with age zero fluid entering was for the fluid age to increase before decreasing to a limiting value. The pressure gradient was highly dependent on the fluid's rheological properties near the wall. Therefore, the pressure gradient fell and then rose slightly with the duration of flow for points near the entrance.

The set of curves shown in Figure 18 describe the change in pressure drop with flow rate at various durations of shear. This results from a cross-plot of the pressure drop responses at three flow rates, one of which appeared in Figures 15 and 16. The superimposed curve intersecting the other profiles represented the pump characteristic, defining the unique path through which flow rate and pressure drop can eventually reach steady-state.

These values are then shown as a function of time in Figure 19. By substituting another pump characteristic curve

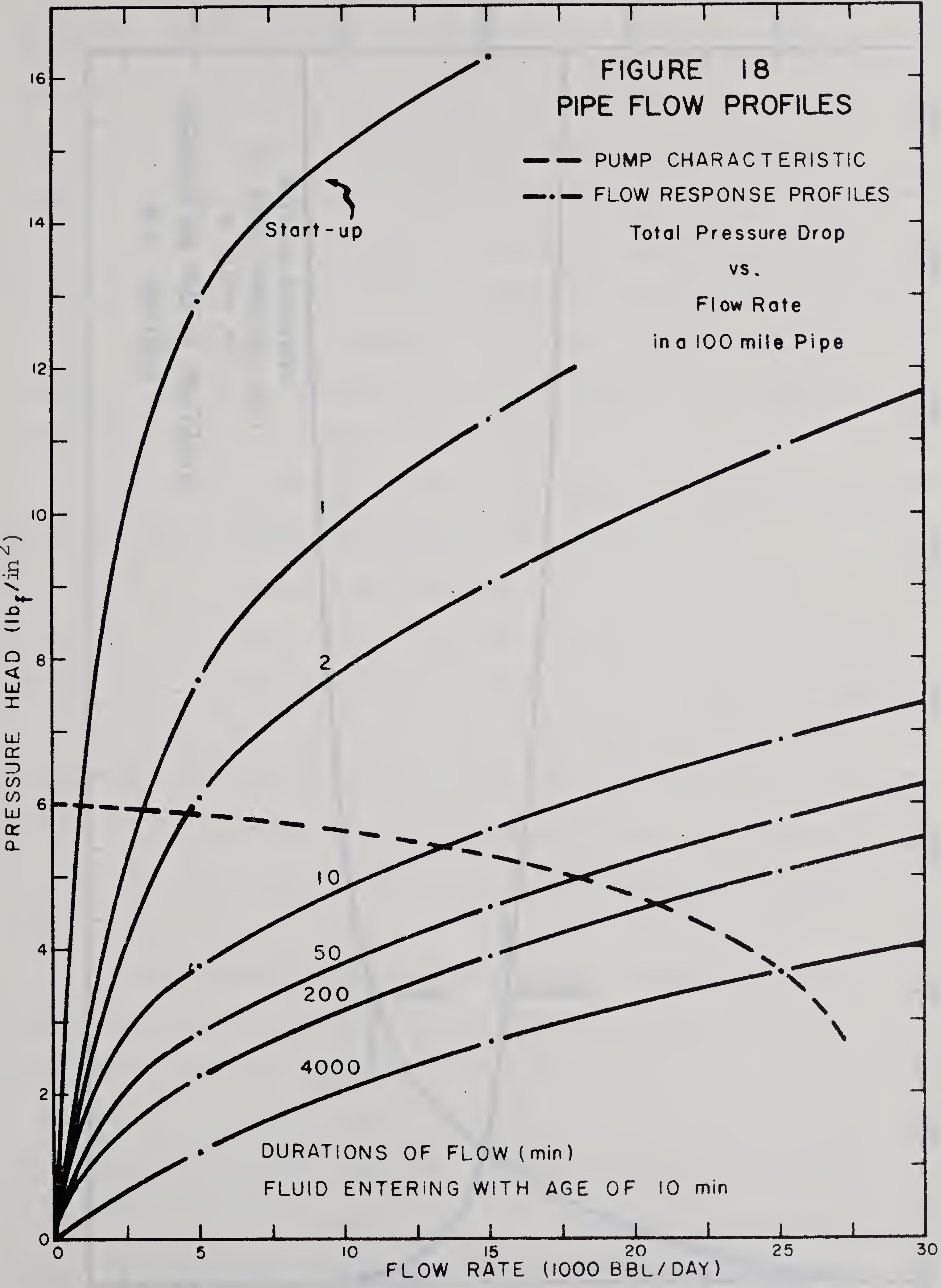


FIGURE 18
PIPE FLOW PROFILES

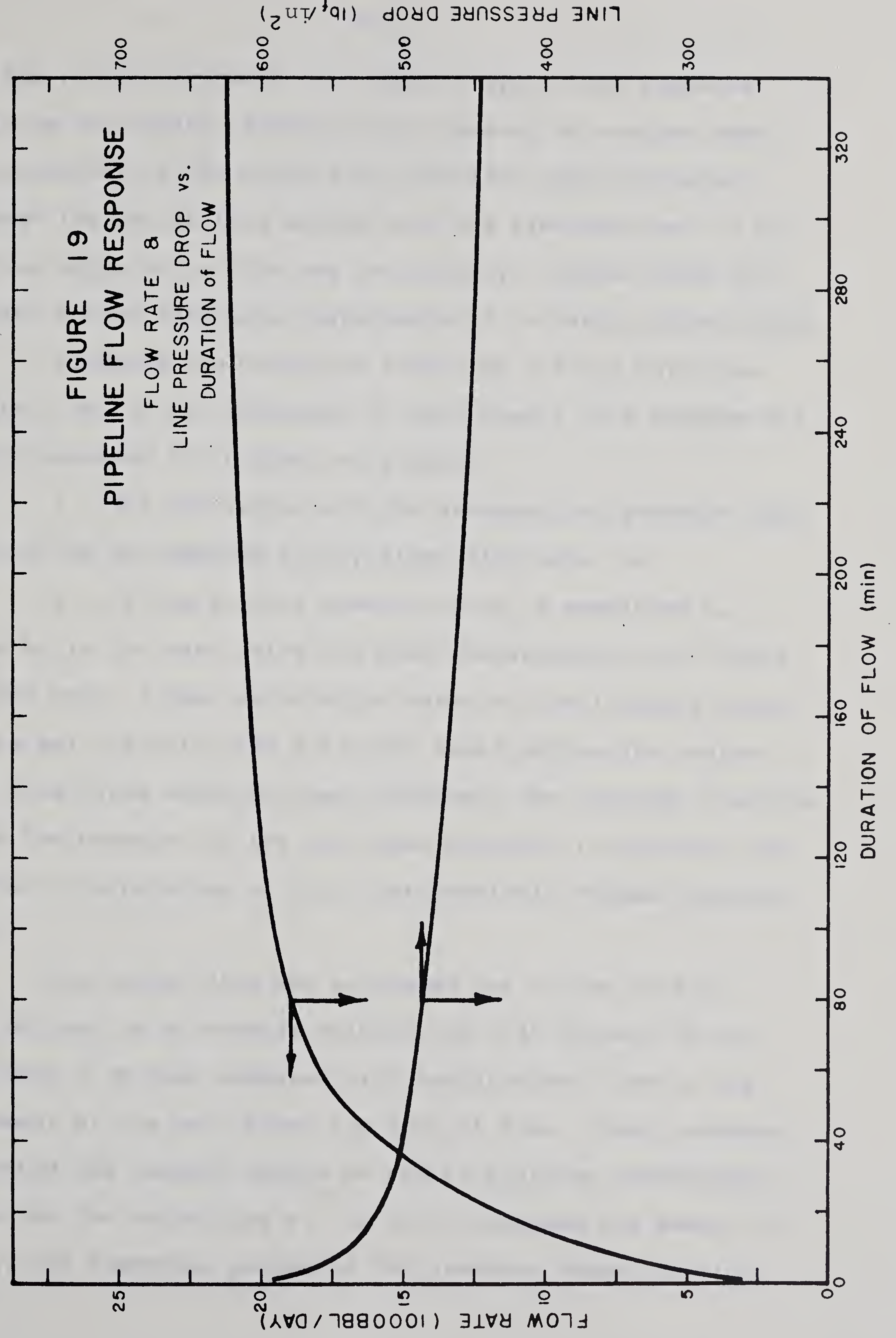


FIGURE 19
PIPELINE FLOW RESPONSE
FLOW RATE & LINE PRESSURE DROP vs. DURATION of FLOW

for the one in Figure 17, the exact shape of the response could be controlled, enabling the choosing of another pump. For instance, if the originally specified pump indicated through the use of this method that the time required to attain an appreciable flow was too lengthy, another pump displaying a more desirable characteristic is easily substituted.

Although the condition involving a fluid which exhibits a gel is not presented in this thesis, the problem has been programmed to include two aspects:

1. The gel radius and the accompanying pressure drop profile can be computed at any given flow rate, or

2. If the initial pressure drop is specified as would be in the case using the pump characteristic of Figure 18 (600 psi), a hand calculation based on the limiting stress of the gel (in this case 0.47 psf) would define its radius. Then this value would be used throughout the thorough analysis. Since the behavior of the gel after yielding is unknown, any further incorporation of this characteristic becomes speculative.

The radial flow was estimated (at a flow rate of 5000 bbl/day or an average velocity of 0.41 ft/sec) to be less than 0.3% when compared with longitudinal flow in the increment at the wall after ten feet of flow. This increment indicated the largest change in radial position encountered since the low velocities at the wall increased the amount of aging, and therefore presented the greatest change in fluid

consistency when compared with the rest of the pipe cross-section. The assumption that shear stress changes linearly with radius appears reasonable on this basis.

The program proved to be unstable if the convergent limits chosen were not suitable. As an example, if the tolerance of the limit used in establishing distances between the longitudinal cross-sections was not small enough, the pressure gradient showed an oscillation along the pipe. In order to obtain convergent values of the pressure gradient, a short section of pipe was tested. By varying the limits, the effect on various parameters was ascertained and the tolerances were changed to provide the desired accuracy.

CONCLUSION

The method presented here for predicting the pressure drop for a thixotropic fluid in steady and unsteady state results in the extension of the hand calculational procedure devised by Govier and Ritter(3). No attempt was made to account for the turbulent flow regime, since the transitional region, in which mixing occurs, could not be represented with composite ages or age profiles. Savins and Cox(12), while attempting to describe design procedures for this type of flow, have over-looked the effect of the aging process on the pressure gradient. Their analysis presented the pipeline design criteria for a complex rheological structure which was dependent on temperature only, a facet that was not investigated here.

The reliability of the program that was developed is based on accepting the shear stress decay data as a representation of the rheological properties of a fluid. The assumption is made that shear rate is uniquely related to shear stress at any specified time with the expectation that the structural growth adjustment within the fluid is minor in comparison to the component already represented and also that this growth adjustment is rapid. The inclusion of a pump into the analysis is even more dependent on this tenet.

An experimental program is currently being planned with the aim of establishing 1) the reliability of the program,

2) the accuracy of the transient flow rate and pressure drop responses that were predicted, and 3) the behavior of the gel under shear. The result will indicate whether or not an attempt must be made to include shear stress growth into the model and also will direct further modifications.

NOMENCLATURE

A	Area of pipe, ft^2
g_c	Dimensional conversion factor, $lb_m ft/lb_f sec^2$
K	Fluid consistency index, $lb_m/ft\ (sec)^{2-n}$
K'	Fluid consistency index, $lb_m/ft\ (sec)^{2-n'}$
k_A	Network decay rate constant
k_B	Network growth rate constant
L	Length, ft
n	Flow behavior index
n'	Flow behavior index
P	Pressure, lb_f/ft^2
ΔP	Pressure drop, lb_f/ft^2
Q	Volumetric flow rate, ft^3/sec
R	Pipe radius, ft
r	Radius, ft
Re	Generalized Reynolds number
t	Time, min.
V	Velocity, ft/sec
V_A	Average velocity, ft/sec
V_R	Velocity at pipe wall, ft/sec
V_r	Velocity at radius r, ft/sec
v	Velocity in direction of flow, ft/sec
y	Distance between shear planes, ft
dv/dy	Shear rate, sec^{-1}
dv/dr	Shear rate, sec^{-1}

Greek Symbols

μ	Viscosity, lb_m/ft.sec
μ'	Coefficient of rigidity, lb_m/ft.sec
μ_A	Apparent viscosity evaluated at wall shear stress lb_m/ft.sec
ρ	Fluid density, lb_m/ft^3
τ	Shear stress, lb_f/ft^2
τ_s	Structural component of shear stress, lb_f/ft^2
τ_w	Shear stress at the wall, lb_f/ft^2
τ_y	Yield stress of a Bingham Plastic, lb_f/ft^2
τ_μ	Newtonian Component of shear stress, lb_f/ft^2

Subscripts

i	Refers to streamline
j	Refers to pipe cross-section
m	Refers to streamline
o	Refers to initial condition
1	Parameter evaluated after 1 minute
∞	Refers to equilibrium value

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APPENDIX 1

NUMERICAL TECHNIQUES

1. Lagrangian Interpolation Polynomial(20)

A polynomial of degree n is known to be uniquely specified by n+1 constants or n+1 points. With (n+1) points in which $x_1-x_o \neq x_2-x_1 \neq \ldots \neq x_n-x_{n-1}$ an interpolation polynomial of degree n is written in the form.

$$\begin{aligned}\phi_n(x) = {} & a_o(x-x_1)(x-x_2)\ldots(x-x_n) \\ & + a_1(x-x_o)(x-x_2)\ldots(x-x_n) \\ & + \ldots \\ & + a_n(x-x_o)(x-x_1)\ldots(x-x_{n-1}) \qquad (1\text{-}1)\end{aligned}$$

with coefficients $a_o, a_1, \ldots, a_n$.

Setting $x = x_o$, then $y_o = \phi(x_o)$. For a given set of data,

$$y_o = a_o(x_o - x_1)(x_o - x_2)\ \ldots\ (x_o - x_n)$$

yielding the constant a_o,

$$a_o = \frac{y_o}{(x_o - x_1)(x_o - x_2)\ldots(x_o - x_n)}$$

The remaining coefficients are found in a similar manner to produce the interpolation polynomial

$$\phi_n(x) = \frac{(x - x_1)(x - x_2)\ldots(x - x_n)}{(x_o - x_1)(x_o - x_2)\ldots(x_o - x_n)}\, y_o$$

$$+ \frac{(x - x_o)(x - x_2)\ldots(x - x_n)}{(x_1 - x_o)(x_1 - x_2)\ldots(x_1 - x_n)} y_1$$

$$+ \ldots$$

$$+ \frac{(x - x_1)(x - x_2)\ldots(x - x_{n-1})}{(x_n - x_o)(x_n - x_1)\ldots(x_n - x_{n-1})} y_n \qquad (1\text{-}2)$$

Setting

$$\beta_n(x) = (x - x_o)(x - x_1)\ldots(x - x_{n-1})(x - x_n)$$

then

$$\frac{d\beta_n(x_j)}{d\ x} \text{ becomes } (x_j - x_o)(x_j - x_1)\ldots(x_j - x_{j-1})$$

$$(x_j - x_{j+1})\ldots(x_j - x_n)$$

and

$$\phi_n(x) = \sum_{j=0}^{n} \frac{\beta_n(x)}{(x - x_j)\ \beta_n'(x_j)} y_j \qquad (1\text{-}3)$$

represents the Lagrangian interpolation polynomial.

2. Gaussian Quadrature(21)

Gaussian quadrature is one of the more accurate integration techniques. An abbreviated development of it follows.

If the degree of curvature of a line to be represented by n+1 points is greater than n, say by r, then there exist (r+1) values on the interval between x_o and x_n at which the

n^{th} derivative of y(x) vanishes; the complete term is non-vanishing. The Lagrangian polynomial, along with the remainder term, obtained from a determination of coefficients is

$$y(x) = \sum_{j=0}^{n} \frac{\beta_n(x)}{(x - x_j)\beta_n'(x_j)} + \frac{\beta_n(x)}{(n)!} y^{(n)}(x) \qquad (1\text{-}4)$$

Integration of the polynomial from a to b

$$\int_a^b y(x)dx = \sum_{j=0}^{n} \left(\int_a^b \frac{\beta_n(x)}{(x - x_j)\beta_n'(x_j)} dx\right) y(x_j)$$

$$+ \int_a^b \frac{\beta_n(x)}{n!} y^{(n)}(x)\, dx$$

and setting the "weighting" function

$$H_j = \int_a^b \frac{\beta_n(x)}{(x - x_j)\beta_n'(x_j)} dx$$

then

$$\int_a^b y(x)dx = \sum_{j=0}^{n} H_j\, y(x_j) + \int_a^b \frac{\beta_n(x)}{n!} y^{(n)}(x)\, dx$$

By representing $y^{(n)}(x)$ by an orthogonal Legendre Polynomial of degree n, the Product $\beta_n(x)\ y^n(x)$ represents a polynomial of degree 2n+1. Since the product is zero at the roots of the orthogonal polynomial H_j's can be evaluated at those points, and the integral "exactly" represents a polynomial of degree 2n+1 with n+1 points, i.e.

$$\int_a^b f(x)\,dx = \sum_{j=0}^{n} H_j\, y(x_j) \tag{1-5}$$

3. Golden Interval Iteration(22)

A search plan which is independent of the shape of a function and yet minimizes the maximum interval of uncertainty is known as minimax. Golden interval iteration is such a technique.

Consider an experiment, placed on the interval that remains after j-1 experiments, such as in Figure (1-1).

Then $$L_{j-1} = L_j + L_{j+1} \tag{1-6}$$

where L represents the interval length, and j is the experiment number

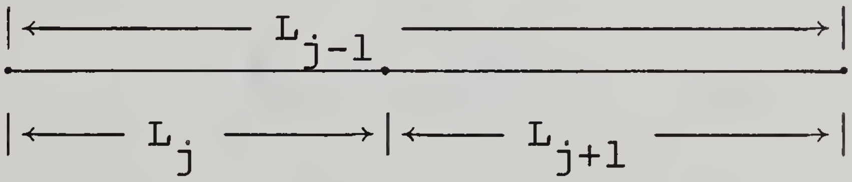


FIGURE 1-1

The points are so spaced that

$$\frac{L_{j-1}}{L_j} = \frac{L_j}{L_{j+1}} \equiv \tau \tag{1-7}$$

Then from (1-7)

$$\frac{L_{j-1}}{L_{j+1}} = \tau^2$$

Substitution into (1-6) yields

$$\tau = \frac{1 + \sqrt{5}}{2.}$$

Consider now two experiments simultaneously placed in Figure

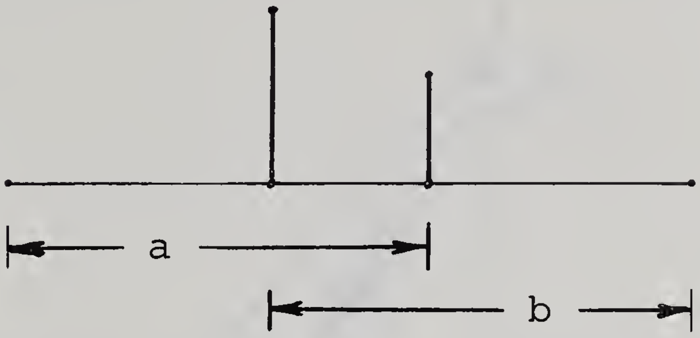


FIGURE 1-2

The interval in which the minimum (maximum) lies is b(a) or if this represents the j-1st experiment, then

$$L_j = \frac{L_{j-1}}{\tau}$$

After n experiments, it can be shown that

$$L_n = \frac{L_I}{\tau^{n-1}} \qquad (1\text{-}8)$$

where L_I is the initial interval length.
$1/\tau^{n-1}$ represents the reduction of the interval length after n experiments regardless of the dependent variable's functionality.

4. Reguli-falsi(20)

Reguli-falsi is a simple method for finding the root of a function through iteration. If the function is pictured by Figure (1-3), then the n+1st trial of x

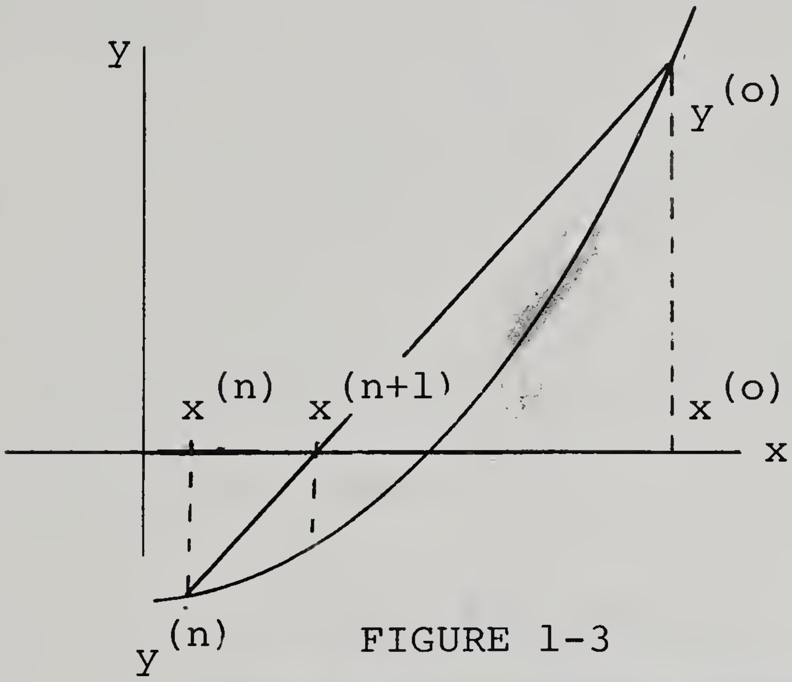


FIGURE 1-3

is given by

$$x^{(n+1)} = \frac{x^{(n)} - y^{(n)}(x^{(n)} - x^{(o)})}{(y^{(n)} - y^{(o)})} \qquad (1\text{-}9)$$

where subscript o represents the base point.

Although it was not necessary for the program presented by this thesis, in the process of its development a curve on which there was an infection at the x-axis was encountered. By moving the base point when $y^{(n)}$ became positive, it was possible to obtain a solution in about one half to one third of the number of trials required by Golden Interval.

APPENDIX 2

USE OF LAGRANGIAN INTERPOLATION

The equation of state was represented mathematically by

$$\left(-\frac{dv}{dr}\right) = \phi(\tau,t) \qquad (2\text{-}1)$$

Discrete values of data represented the surface so that (2-1) becomes

$$\left(-\frac{dv}{dr}\right)_{i,j} = \phi(\tau_i,\ t_{i,j})$$

In order to obtain the required value (-dv/dr)* for τ^* and t^* the interpolation first affixed a position to shear stress and time as in Figure (2-1). Then, use of the

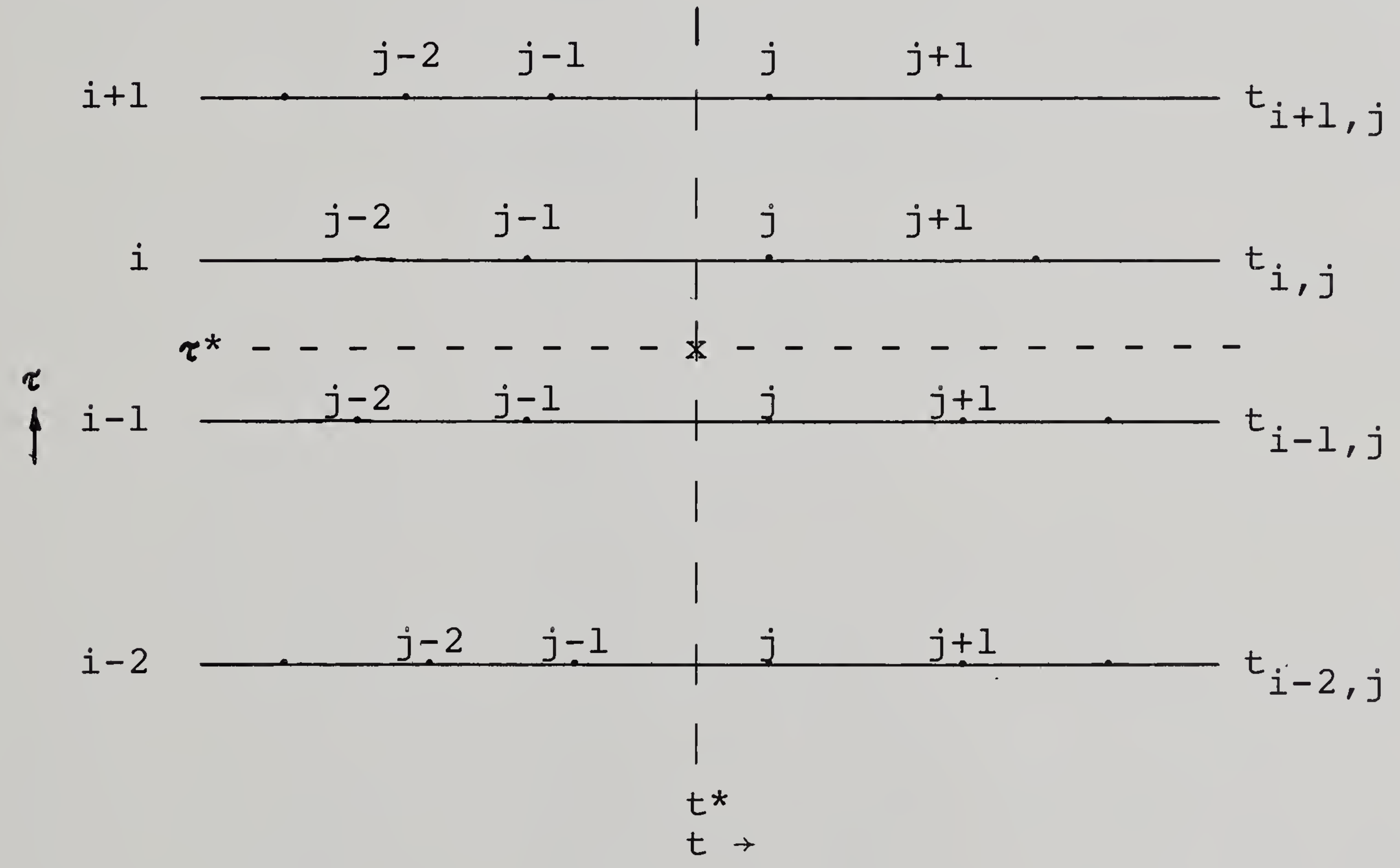
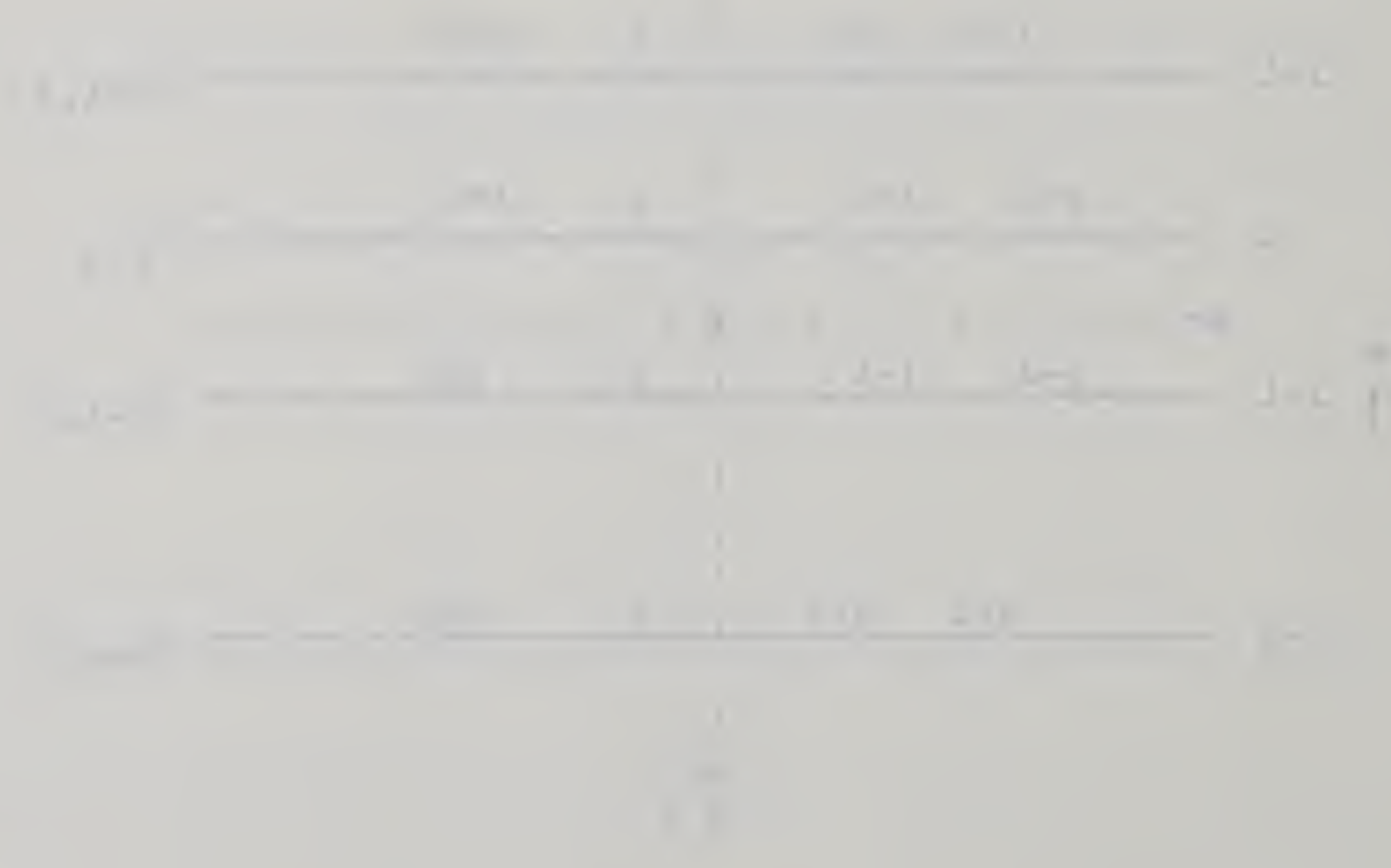


FIGURE 2-1

[illegible]



[illegible]

interpolation yielded values of shear rate making shear rate a function of shear stress.

$$\left(\frac{dv}{dr}\right)_{i,j} = \phi_j(\tau_i)$$

The final interpolation along the t* line produced (-dv/dr)*. This interpolation has been programmed in Fortran IV in subroutine 'INTERB' in Appendix 3 .

APPENDIX 3

COMPUTER PROGRAMS

```
C   THIS PROGRAM CALCULATES THE PRESSURE DROP ALONG A PIPE FOR
C   A THIXOTROPIC FLUID.
C   THE PROGRAM IS WRITTEN IN FORTRAN IV.
C   THIS IS THE CONTROL SUBROUTINE, READING IN ALL
C   NECESSARY DATA.
C   ALL 'READ' FORMAT STATEMENTS APPEAR AS A BLOCK AT THE
C   BEGINNING OF THE DATA.
C
C    LIST OF SYMBOLS
C       JWRITE  - FLAG INTEGER. IF GREATER THAN ZERO, FLUID
C                 DATA IS PRINTED.
C       JW1     - FLAG INTEGER. IF GREATER THAN ZERO, EACH
C                 FLOW PROFILE IS PRINTED VIA 'WRIT1'.
C       JW2     - FLAG INTEGER. IF GREATER THAN ZERO, THE
C                 ACCUMULATED PRESSURE DROP AT EACH DURATION OF
C                 FLOW IS PRINTED VIA 'WRITE2'.
C       JS      - NUMBER OF DATA VALUES OF SHEAR STRESS.
C       GTOW( ) - SHEAR STRESS VALUES IN DATA (LB/SQ FT X 1000).
C       JT( )   - NUMBER OF DATA VALUES OF TIME AND SHEAR
C                 RATE AT EACH SHEAR STRESS (I.E. UP TO JS).
C       GT( , ) -FLUID AGE MATRIX, I.E. A VECTOR OF AGES AT
C                 EACH SHEAR STRESS (MIN).
C       GDVDR( , ) - SHEAR RATE MATRIX, I.E. A VECTOR OF
C                 SHEAR RATE CORRESPONDING TO EACH SHEAR STRESS
C                 (1/SEC).
C       QP      - FLOW RATE.
C       JV      - FLAG INTEGER DESCRIBING FLOW RATE UNITS.
C                 IF JV IS GREATER THAN 0, BBL/DAY
C                 IF JV IS LESS THAN OR EQUAL TO 0, CU FT/SEC.
C       RHO     - FLUID DENSITY (LB/CU FT).
C       XL      - PIPE LENGTH(FT).
C       RF      - PIPE RADIUS (FT).
C       DELTAL  - LENGTH INCREMENT TRIAL SIZE (FT).
C       REC     - CONSTANT FOR OBTAINING REYNOLDS NO. (SQ FT/LB).
C       VA      - AVERAGE VELOCITY (FT/SEC).
C       TINIT   - AGE OF ENTERING FLUID (MIN).
C       TOWMIN  - LIMITING STRESS - IF ONE EXISTS (LB/SQ FT).
C       RA      - IS THE GEL RADIUS.
C       N       - TRIAL NUMBER OF RADIAL INCREMENTS.
C       NMAX    - MAXIMUM VALUE OF N NECESSARY.
C       EPS1    - CONVERGENCE LIMIT IN 'INITPR' ON FLOW ERROR.
C       EPS2    - CONVERGENCE LIMIT IN 'INITPR' FOR ESTABLISHING
C                 NUMBER OF RADIAL INCREMENTS.
C       EPS3    - CONVERGENCE LIMIT IN 'RADII' FOR CHANGING
C                 STREAMLINE POSITIONS.
C       EPS4    - CONVERGENCE LIMIT IN 'OPTIM' ON FLUID AGES.
C       EPS5    - INITIAL CONVERGENCE LIMIT IN 'OPTIM' FOR
C                 WALL SHEAR STRESS.
C       EPS6    - FINAL CONVERGENCE LIMIT IN 'OPTIM' FOR WALL
C                 SHEAR STRESS.
C       EPS7    - CONVERGENCE LIMIT IN 'LENGTH' FOR
C                 ESTABLISHING LONGITUDINAL POSITIONS.
```

```
C       TT( )     - VECTOR OF FLOW DURATIONS TO BE CALCULATED.
C       NT        - NUMBER OF FLOW DURATIONS.
C       NNN       - FLAG INTEGER. IF GREATER THAN ZERO, A NEW SET
C                   OF CONDITIONS ON THE SAME FLUID IS READ.
      REAL F1(12), F2(12), F3(12), F4(12), F5(12), F6(12),
     1 F7(12), F8(12), F9(12), F10(12)
      REAL GTOW(30), GT(30,30), GDVDR(30,30), QP, QG, RF, DELTAL,
     1 TINIT, TOWMIN, EPS1, EPS2, EPS3, EPS4, EPS5, EPS6, EPS,
     2 TT(10), REC, XL, RR, RHO, VA
      INTEGER I, J, JS, JT(30), JXA, JWRITE, JV, N, NMAX, JW1,
     1 JW2, NT, NNN
 100  FORMAT(12A6)
 101  FORMAT(1HK,14X,25HTHE AVG. VELOCITY IS THEN,F7.4,
     1 8H FT/SEC.)
 102  FORMAT(1HK,14X,26HTHE RADIUS OF THE PIPE IS ,F5.2,4H FT.)
 103  FORMAT(1HK,14X,27HTHE DENSITY OF THE FLUID IS,F7.3,
     1 10H LB/CU FT.)
 104  FORMAT(1HK,14X,28HITS LIMITING SHEAR STRESS IS,F6.3,
     1 10H LB/SQ FT.)
 105  FORMAT(1HK,13X,I2,2X,25HFLOW AGES ARE CALCULATED.)
 106  FORMAT(1H1,14X,9HTHERE ARE,I3,24H VALUES OF SHEAR STRESS.)
 107  FORMAT(1HK,14X,8HFOR TOW(,I3,4H ) =,F10.4,11H ,THERE ARE,
     1 I3,13H DATA POINTS.)
 108  FORMAT(1HJ,14X,3(20H   TIME - SHEAR RATE))
 109  FORMAT(1H3,14X,17HTHE FLOW RATE IS ,F11.3,2X,11HBBL/DAY OR,)
 110  FORMAT(1HK,14X,17HTHE FLOW RATE IS ,F11.8,3X,
     1 19HCUBIC FEET PER SEC.)
 111  FORMAT(1H ,14X,6F10.4)
 112  FORMAT(1HK,14X,18HTHE PLUG RADIUS IS,F8.5,4H FT.)
      READ(5,100) F1, F2, F3, F4, F5, F6, F7, F8, F9, F10
      READ(5,F1) JS, JWRITE, JW1, JW2
      READ(5,F2) (GTOW(J), J=1,JS)
      READ(5,F3) (JT(J), J=1,JS)
      DO 900 J=1,JS
      JXA=JT(J)
 900  READ(5,F4) (GT(I,J), GDVDR(I,J), I=1,JXA)
      IF (JWRITE.LT.1) GO TO 901
      WRITE(6,106) JS
      DO 902 J=1,JS
      JXA=JT(J)
      WRITE(6,107) J, GTOW(J), JXA
      WRITE(6,108)
 902  WRITE(6,111) (GT(I,J), GDVDR(I,J), I=1,JXA)
 901  READ(5,F5) QP, JV, RHO, XL
      WRITE(6,109) QP
      QG=QP
      IF (JV.GT.0) QG=QP*0.64983333E-04
      IF (JV.GT.0) WRITE (6,110) QG
      READ(5,F6) RF, DELTAL, TINIT, TOWMIN, N, NMAX, RA
      READ(5,F7) EPS1, EPS2, EPS3, EPS4, EPS5, EPS6, EPS7
      VA=QG/(3.1415927*RF**2)
      READ(5,F8) NT
```

```
 READ(5,F9)  (TT(I), I=1,NT)
 WRITE(6,102) RF
 RR=RF-RA
 WRITE(6,112) RA
 WRITE(6,101) VA
 WRITE(6,103) RHO
 WRITE(6,104) TOWMIN
 WRITE(6,105) NT
 REC=8.*VA**2*RHO/32.2
 CALL TIME (TINIT, JS, JT, GTOW, GT, GDVDR, DELTAL, QG, N,
1 NMAX, TOWMIN, RF, EPS1, EPS2, EPS3, EPS4, EPS5, EPS6,
2 REC, JW1, JW2, TT, NT, EPS7, XL, RR)
 READ(5,F10) NNN
 IF (NNN.LT.1) CALL EXIT
 GO TO 901
 END
```

```
      SUBROUTINE INITPR (V1, R1, T, TW, RR, RF, N, JT, JS, GT,
     1 GTOW, GDVDR, KOT, Q2, TOWMIN, KA, QG, EPS1, EPS2, NMAX,
     2 VZ)
C   'INITPR' IS CALLED BY 'TIME' AND BY 'LENGTH'.
C   'INITPR' USES GOLDEN INTERVAL ITERATION TO ESTABLISH THE
C   CORRECT VALUE OF SHEAR STRESS AT THE WALL IN A PIPE OF
C   RADIUS, R, AT A CONSTANT FLOW RATE, QG, FOR A CONSTANT AGE
C   MATERIAL.  INCREMENTAL FLOW RATES ARE PROVIDED ACCURATELY
C   AFTER THE NUMBER OF INCREMENTS HAVE BEEN CONVERGED UPON.
C
C     LIST OF SYMBOLS
C        GDVDR( , )- DATA SHEAR RATES (1/SEC).
C        GT( , )   - DATA SHEAR DURATIONS (MIN).
C        GTOW( )   - DATA SHEAR STRESSES (LB/SQ FT X 1000).
C        JS        - NUMBER OF VALUES IN SHEAR STRESS VECTOR AND
C                    LIMIT OF SECOND SUBSCRIPT OF OTHER TWO
C                    VARIABLES.
C        JT        - FIRST SUBSCRIPT LIMIT.
C        TW      - SHEAR STRESS AT WALL (LB/SQ FT).
C        TB      - SAME VALUE AT PREVIOUS NUMBER OF INCREMENTS.
C        V1( )   - VELOCITY POINTS (FT/SEC).
C        R1( )   - RADIAL POSITIONS (FT), MEASURED FROM WALL.
C        RF      - PIPE RADIUS (FT).
C        RA( )   - RADII OF VELOCITY POINTS (FT), RF-R1( ).
C        I       - INTEGER SPECIFYING RADIAL INCREMENT FROM
C                  RA(I+1) TO RA(I), NUMBERED FROM WALL.
C        Q2( )   - INCREMENTAL FLOW RATE VECTOR (CU FT/SEC).
C        N       - NUMBER OF RADIAL INCREMENTS.
C        NP      - NUMBER OF STREAMLINES IN NON-GEL FLOW REGION.
C        IA      - NUMBER OF INCREMENTS IN NON-GEL REGION.
C        S1      - LOWER LIMIT OF GOLDEN INTERVAL SEARCH.
C        S2      - UPPER LIMIT OF GOLDEN INTERVAL SEARCH.
C        TOWMIN  - LIMITING STRESS OF FLUID.
C        RR      - WIDTH OF NON-PLUG REGION.
C        T( )    - FLUID AGE VECTOR AT QUADRATURE POSITIONS (MIN).
C        VEL     - INCREMENTAL INCREASE IN VELOCITY.
C        FQ      - INCREMENTAL FLOW RATE.
C        QSUM    - TOTAL CALCULATED FLOW RATE.
C        QG      - TOTAL GIVEN FLOW RATE.
C        AQD     - ABSOLUTE ERROR IN FLOW RATE.
C        AAA     - PREVIOUS VALUE OF AQD.
C        ATD     - ERROR IN SHEAR STRESS AT TWO NUMBERS OF RADIAL
C                  INCREMENTS.
C        NMAX    - MAXIMUM NUMBER OF RADIAL INCREMENTS ACCEPTABLE
C                  TO PROGRAMMER.
      REAL V1(35), R1(35), RA(35), Q2(35), T(100), GTOW(30),
     1 GT(30,30), GDVDR(30,30), RF, RR, RI, A, B, QSUM, FQ, DR,
     2 S1, S2, SA, SB, AQD, AQD1, AQD2, ATD, TB, TW, TOWMIN, QG,
     3 EPS1, EPS2, AAA, VZ(100), VEL
      INTEGER I, N, NP, IA, I1, KOT, KA, M, NMAX, JT(30), JS, NN
C        INITIALIZE PROBLEM.
```

```
      AQD=0.00
      TB=0.00
      V1(1)=0.00
      RA(1)=RF
      R1(1)=0.00
C        INITIATE GOLDEN INTERVAL SEARCH FOR WALL SHEAR STRESS.
      M=0
      S1=GTOW(1)/1000.
      S2=GTOW(JS)/1000.
C        SELECT TRIAL VALUE OF WALL SHEAR STRESS.
   11 CALL GOLDIT (M, S1, S2, TW, AQD, SA, SB, AQD1, AQD2)
C        IF NO GEL EXISTS, GO TO 12.
      IF (KOT.EQ.0) GO TO 12
C        IF THE PLUG RADIUS HAS BEEN SELECTED, GO TO 9
      IF (KOT.EQ.1) GO TO 9
C        CFLCUALTE WIDTH OF NON-PLUG SECTION.
      RR=RF-TOWMIN*RF/TW
C        IF IT IS NEGATIVE GO TO 24.
      IF (RR.LE.0.00) GO TO 24
C        EXTABLISH NUMBER OF INCREMENTS IN NON-PLUG REGION.
    9 RI=N
      RI=RF/RI
      IA=RR/RI
      IA=IA+1
      IF (IA.EQ.N) N=N+1
      NP=IA+1
C        DEPLOY RADII PARABOLICALLY.
      B=IA
      DO 10 I=2,NP
      A=NP-I
   10 R1(I)=RR*(1.-(A/B)**0.5)
      GO TO 14
   12 CONTINUE
C        DEPLOY RADII PARABOLICALLY FOR NO-GEL CONDITION.
      NP=N+1
      IA=N
      B=N
      DO 13 I=2,NP
      A=NP-I
   13 R1(I)=RF*(1.-(A/B)**0.5)
   14 NN=3*N
C        DEFINE CONSTANT TIME VECTOR.
      DO 4 I=1,NN
    4 T(I)=T(1)
C        CALCULATE VELOCITY PROFILE.
      DO 1 I=2,NP
      CALL SINT (JT, JS, GT, GTOW, GDVDR, T, TW, KA, R1, I, VEL,
     1 RF)
      IF (KA.EQ.1) RETURN
      V1(I)=V1(I-1)+VEL
    1 RA(I)=RF-R1(I)
C        CALCULATE INCREMENTAL AND TOTAL FLOWS.
```

```
      QSUM=0.00
      DO 2 I=1,IA
      CALL INTEGR (V1, RA, I, NP, FQ, VZ)
      Q2(I)=FQ
  2   QSUM=QSUM+FQ
C        IF NO GEL EXISTS, GO TO 22
      IF(KOT.EQ.0) GO TO 22
      DR=N-IA
C        SELECT RADII, AND CALCULATE INCREMENTAL FLOW RATES IN
C        PLUG REGION.
      DR=(RF-RR)/DR
      DO 21 I=NP,N
      I1=I+1
      V1(I1)=V1(NP)
      R1(I1)=R1(I)+DR
      Q2(I)=3.1415927*((RF-R1(I))**2-(RF-R1(I1))**2)*V1(NP)
 21   QSUM=QSUM+Q2(I)
 22   CONTINUE
      AAA=AQD
C        CALCULATE FLOW RATE ERROR.
      AQD=ABS((QG-QSUM)/QG)
C        IF IT HAS CHANGED FROM ITS PREVIOUS VALUE, GO TO 25.
      IF (ABS(AQD-AAA).GT.1.0E-30) GO TO 25
C        NO FURTHER CONVERGENCE POSSIBLE, PRINT OUT LIMIT
C        ATTAINED.
      WRITE(6,27) AQD, EPS1
 27   FORMAT(1H , 20HTHE MINIMUM ERROR IS,E15.8,2X,11HWITH EPS1 =,E15.
      AQD=1.0E-30
C        IF ERROR IS NOT TOLERABLE, REPEAT PROCEDURE.
 25   IF(AQD.GT.EPS1) GO TO 11
C        CHECK FOR WALL STRESS CONVERGENCE AT TWO INCREMENT SIZES.
      ATD=ABS((TW-TB)/TW)
C        PREPARE TO RE-ESTABLISH SHEAR FOR SHEAR STRESS.
      M=0
      S1=(1.-ATD)*TW
      S2=(1.+ATD)*TW
C        IF WALL STRESS IS CONVERGED, GO TO 20
      IF(ATD.LT.EPS2) GO TO 20
C        IF NUMBER OF ALLOWABLE INCREMENTS IS EXCEEDED, GO TO 20.
      IF (N.GE.NMAX) GO TO 20
C        IF NUMBER IS GREATER THAN 32, GO TO 20.
      IF (N.GE.32) GO TO 20
      TB=TW
C        INCREASE NUMBER OF INCREMENTS BY 2.
      N=2+N
      GO TO 11
C        REDEFINE SEARCH RANGE.
 24   M=0
      S1=TW
      GO TO 11
 20   RETURN
      END
```

```
      SUBROUTINE INTCON (V, RA, NP, FQ, A, B)
C   'INTCON' IS CALLED BY 'RADII'.
C   'INTCON' FINDS THE VOLUMETRIC FLOW RATE BETWEEN TWO STREAM-
C   LINES USING GAUSSIAN QUADRATURE ON A LAGRANGIAN INTERPOLATED
C   PROFILE.
C
C     LIST OF SYMBOLS
C        V( )    - INPUT VELOCITY PROFILE (FT/SEC) AT
C        RA( )   - SPECIFIED RADII (FT).
C        NP      - NUMBER OF POINTS IN PROFILE (NUMBERED FROM
C                  WALL).
C        A       - INNER STREAMLINE RADIUS (FT).
C        B       - OUTER STREAMLINE RADIUS (FT).
C        M       - INTEGER SPECIFYING QUADRATURE POINT NUMBER (1
C                  TO 3).
C        LAMBDA  - QUADRATURE LOCATION ON THE RANGE FROM -1 TO
C                  +1.
C        H       - WEIGHTING FACTOR ON INTEGRAL AT LAMBDA.
C        X       - ACTUAL PIPE RADIUS SPECIFIED BY LAMBDA.
C        I       - LOCATION OF X AMONG RA( ) FOR INTERPOLATION
C                  POLYNOMIAL.
C        K1      - LOWER EXTENT OF INTERPOLATION POLYNOMIAL.
C        K2      - UPPER EXTENT OF INTERPOLATION POLYNOMIAL.
C        YP      - VALUE OF FUNCTION FROM INTERPOLATION
C                  POLYNOMIAL.
C        YOFX    - PRODUCT OF VELOCTIY TIMES RADIUS AT X -
C                  REQUIRED INTEGRAL.
      REAL V(35), RA(35), FQ, CONST, H, LAMBDA, X, YOFX, XR, YP,
     1 A, B
      INTEGER NP, M, I, K1, K2, IJ, JJ, J
C        INITIALIZE INTEGRATION.
      CONST=6.2831853
      FQ=0.00
      M=1
C         SELECT VALUE OF LAMBDA AND H FOR A GIVEN VALUE OF M.
 130  GO TO (131, 132, 133), M
 131  LAMBDA=-0.77459667
      H=0.55555555
      GO TO 134
 132  LAMBDA=0.00
      H=0.88888888
      GO TO 134
 133  LAMBDA=+0.77459667
      H=0.55555555
C         CALCULATE VALUE OF RADIUS CORRESPONDING TO LAMBDA.
 134  X=(LAMBDA*(B-A)+A+B)/2.00
C        LOCATE X IN THE VELOCITY PROFILE.
      DO 160 J=1,NP
      I=J
 160  IF (X.GT.RA(J)) GO TO 161
C        ESTABLISH RANGE OF THIRD-ORDER POLYNOMIAL.
```

```
 161  K1=I-2
      K2=I+1
C        AT LOW END OF VELOCITY PROFILE MAKE INTERPOLATION
C        LINEAR.
      IF (K1.GE.1) GO TO 165
      K1=1
      K2=2
C        AT TOP OF PROFILE MAKE INTERPOLATION SECOND ORDER AND
C        SYMMETRIC ABOUT PIPE CENTRELINE.
 165  IF (K2.LE.NP) GO TO 164
      RA(K2)=-RA(K2-2)
      V(K2)=V(K2-2)
 164  CONTINUE
C        CALCULATE INTERPOLATION POLYNOMIAL AND OBTAIN PRODUCT OF
C        VELOCITY * RADIUS.
      YOFX=0.00
      DO 163 IJ=K1,K2
      YP=1.00
      DO 162 JJ=K1,K2
      IF (JJ.EQ.IJ) GO TO 162
      XR=(X-RA(JJ))/(RA(IJ)-RA(JJ))
      YP=YP*XR
 162  CONTINUE
 163  YOFX=YOFX+V(IJ)*RA(IJ)*YP
C        CALCULATE WEIGHTED PORTION OF INTEGRAL CORRESPONDING
C        TO VALUE OF M.
      FQ=FQ+H*YOFX
C        INCREASE M BY 1 AND CHECK FOR COMPLETION OF INTEGRATION.
      M=M+1
      IF (M.LE.3) GO TO 130
C        CONVERT INTEGRAL ON RANGE -1 TO +1 INTO INTEGRAL ACROSS
C        INCREMENT AND MULTIPLY BY CONST (2*PI) TO YIELD
C        INCREMENTAL FLOW RATE.
      FQ=FQ*CONST*(B-A)/2.00
      RETURN
      END
```

```
      SUBROUTINE GOLDIT (I,Z1,Z2,Z,FZ,ZA,ZB,FZ1,FZ2)
C   'GOLDIT' IS CALLED BY 'INITPR' AND BY 'RADII'.
C   'GOLDIT' SELECTS TRIAL VALUES OF THE INDEPENDANT VARIABLE
C   ACROSS A SPECIFIED RANGE SO THAT THE DEPENDANT VARIABLE IS
C   MINIMIZED.
C
C     LIST OF SYMBOLS
C        I       - INTEGER SPECIFYING LOCATION OF PREVIOUS SEARCH
C                  VALUE.
C        Z1      - LOWER END OF SEARCH RANGE.
C        Z2      - UPPER END OF SEARCH RANGE.
C        ZA      - LAST SELECTED VARIABLE LEFT OF CENTRE.
C        ZB      - LAST SELECTED VARIABLE RIGHT OF CENTRE.
C        Z       - NEW TRIAL VALUE.
C        FZ      - FUNCTIONAL VALUE AT Z.
C        FZ1     - FUNCTIONAL VALUE AT ZA.
C        FZ2     - FUNCTIONAL VALUE AT ZB.
      REAL FZ, FZ1, FZ2, Z1, Z2, ZA, ZB, Z, D
      INTEGER I
      DOUBLE PRECISION TAU
C        FOR FIRST TRIAL I=0.
      TAU = 1.618033989
C        IF LEFT-HAND POINT CALCULATED LAST GO TO 304.
      IF (I.EQ.3) GO TO 304
C        IF RIGHT-HAND POINT CALCULATED LAST GO TO 305.
      IF (I.EQ.2) GO TO 305
C        IF ONE INITIAL POINT HAS BEEN CALCULATED (LHS),
C        CALCULATE SECOND ONE (RHS).
      IF (I.EQ.1) GO TO 302
      I=1
C        SELECT POINT LEFT OF CENTRE (ZA).
 301  D=ABS((Z1-Z2)/(TAU**2))
      ZA=Z1+D
      Z=ZA
      RETURN
 302  I=2
C        SELECT POINT RIGHT OF CENTRE (ZB), STORE F(ZA) AS FZ1.
      FZ1=FZ
 303  D=ABS((Z1-Z2)/(TAU**2))
      ZB=Z2-D
      Z=ZB
      RETURN
 304  FZ1=FZ
      GO TO 306
C        STORE F(ZB) AS FZ2.  IF BOTH DEPENDANT VARIABLES ARE
C        EQUAL INITIALIZE THE SEARCH.
 305  FZ2=FZ
 306  IF (FZ1.NE.FZ2) GO TO 307
      I=1
      Z1=ZA
      Z2=ZB
```

```
      GO TO 301
C        IF THE RHS IS LOWER THAN LHS DEFINE RANGE TO BE RIGHT OF
C        LH POINT, AND RH POINT BECOMES LH POINT.
 307  IF (FZ1.LT.FZ2) GO TO 308
      I=2
      Z1=ZA
      ZA=ZB
      FZ1=FZ2
      GO TO 303
C        IF THE LHS IS LOWER THAN RHS, DEFINE RANGE TO BE LEFT
C        OF RH POINT, AND AND THE LH POINT BECOMES THE RH POINT.
 308  I=3
      Z2=ZB
      ZB=ZA
      FZ2=FZ1
      GO TO 301
      END
```

```
      SUBROUTINE INTEGR (V, RA, I, NP, FQ, VZ)
C    'INTEGR' IS CALLED BY 'INITPR' AND BY 'SUBINT'.
C    'INTEGR' EMPLOYS GAUSSIAN THREE-POINT QUADRATURE TO PROVIDE
C    AN INCREMENTAL FLOW RATE.  LAGRANGIAN THIRD-ORDER INTERPOLA-
C    TION PROVIDES VALUES OF VELOCITY FROM THE INPUT VELOCITY
C    PROFILE CORRESPONDING TO RADII SELECTED BY QUADRATURE.
C
C     LIST OF SYMBOLS
C        I    - INCREMENT (NUMBERED FROM THE PIPE WALL) FOR
C              WHICH THE FLOW RATE IS CALCULATED.
C       RA( )- RADII OF INPUT PROFILE (FT).
C       V( ) - VELOCITIES CORRESPONDING TO RA( ) (FT/SEC).
C       NP   - NUMBER OF POINTS IN INPUT PROFILE.
C       VZ( )- VELOCITIES AT QUADRATURE LOCATIONS (3 PER
C              INCREMENT).
C       FQ   - INCREMENTAL FLOW RATE (CUBIC FT/SEC).
C       CONST- 2 * PI.
C        A   - INCREMENT INNER RADIUS (FT).
C        B   - INCREMENT OUTER RADIUS (FT).
C        M   - INTEGER SPECIFYING QUADRATURE POINT NUMBER ( 1
C              TO 3).
C       LAMBDA-QUADRATURE LOCATION ON THE RANGE FROM -1 TO +1.
C        H   - WEIGHTING FACTOR ON INTEGRAL AT LAMBDA.
C        X   - ACTUAL RADIUS SPECIFIED BY LAMBDA.
C       K1   - LOWER EXTENT OF INTERPOLATION POLYNOMIAL.
C       K2   - UPPER EXTENT OF INTERPOLATION POLYNOMIAL.
C       YP   - VALUE OF FUNCTION FROM INTERPOLATION POLYNOMIAL.
C       Y2X  - VELOCITY AT X.
C       YOFX - PRODUCT OF VELOCITY TIMES RADIUS AT X.
      REAL V(35), RA(35), FQ, CONST, H, LAMBDA, X, YOFX, XR, YP,
     1 A, B, VZ(100), Y2X
      INTEGER NP, M, I, K1, K2, IJ, JJ, II
C       SPECIFY INCREMENT BOUNDS AND INITIALIZE INTEGRATION.
      CONST=6.2831853
      B=RA(I)
      A=RA(I+1)
      FQ=0.00
      M=1
C       SELECT VALUE OF LAMBDA AND H FOR A GIVEN M.
 130  GO TO (131, 132, 133), M
 131  LAMBDA=-0.77459667
      H=0.55555555
      GO TO 134
 132  LAMBDA=0.00
      H=0.88888888
      GO TO 134
 133  LAMBDA=+0.77459667
      H=0.55555555
C       CALCULATE VALUE OF RADIUS FROM LAMBDA.
 134  X=(LAMBDA*(B-A)+A+B)/2.00
C       DEFINE INTERPOLATION RANGE.
```

```
      K1=I-1
      K2=I+2
C        IF AT PIPE WALL MAKE INTERPOLATION SECOND ORDER.
      IF (K1.LT.1) K1=1
C        IF AT PIPE CENTRE, MAKE INTERPOLATION SECOND ORDER AND
C        SYMMETRIC ABOUT CENTRE.
      IF (K2.LE.NP) GO TO 160
      K1=I
      RA(K2)=-RA(K2-2)
      V(K2)=V(K2-2)
C        CALCUALTE INTERPOLATION POLYNOMIAL AND OBTAIN PRODUCT
C        OF VELOCITY * RADIUS AND VELOCITY AT X.
 160  YOFX=0.00
      Y2X=0.00
      DO 163 IJ=K1,K2
      YP=1.00
      DO 162 JJ=K1,K2
      IF (JJ.EQ.IJ) GO TO 162
      XR=(X-RA(JJ))/(RA(IJ)-RA(JJ))
      YP=YP*XR
 162  CONTINUE
      Y2X=Y2X+V(IJ)*YP
 163  YOFX=YOFX+V(IJ)*RA(IJ)*YP
C        STORE VELOCITY AT X.
      II=3*I-M+1
      VZ(II)=Y2X
C        CALCULATE WEIGHTED PORTION OF INTEGRAL AT M.
      FQ=FQ+H*YOFX
C        INCREASE M BY 1 AND CHECK FOR COMPLETION OF INTEGRATION.
      M=M+1
      IF (M.LE.3) GO TO 130
C        CONVERT INTEGRAL ON RANGE -1 TO +1 INTO INTEGRAL ACROSS
C        INCREMENT AND MULTIPLY BY CONST (2*PI).
      FQ=FQ*CONST*(B-A)/2.00
      RETURN
      END
```

```
      SUBROUTINE INTERB (JX, JY, X, Y, Z, XR, YR, YF, KA)
C   'INTERB' IS CALLED BY 'SINT'.
C   'INTERB' EMPLOYS LAGRANGIAN THIRD-ORDER INTERPOLATION TO
C   OBTAIN A VALUE OF SHEAR RATE FOR SPECIFIED VALUES OF SHEAR
C   STRESS AND TIME.
C
C     LIST OF SYMBOLS
C        Y( )     - DATA VALUES OF SHEAR STRESS * 1000 (LB/SQ FT).
C        L        - INTEGER SUBSCRIPT FOR SHEAR STRESS.
C        JX       - EXTENT OF L - NUMBER OF SHEAR STRESS VALUES.
C        X( , )   - DATA VALUES OF TIME (MIN).
C        Z( , )   - DATA VALUES OF SHEAR RATE. (1/SEC).
C        K        - INTEGER SUBSCRIPT OF TIME AT EACH L.
C        JX( )    - EXTENT OF K AT EACH L.
C        JXA      - VALUE OF JX(L).
C        XR       - VALUE OF SHEAR STRESS * 1000 AT WHICH SHEAR
C                   RATE IS REQUIRED (LB/SQ FT).
C        YR       - VALUE OF TIME AT WHICH SHEAR RATE IS REQUIRED
C                   (MIN).
C        L1       - LOWER END OF SHEAR STRESS INTERPOLATION RANGE.
C        L2       - UPPER END OF SHEAR STRESS INTERPOLATION RANGE.
C        K1       - LOWER END OF TIME INTERPOLATION RANGE, GIVEN L.
C        K2       - UPPER END OF TIME INTERPOLATION RANGE, GIVEN L.
C        XZ       - PARTIAL INTERPOLATION POLYNOMIAL.
C        YP       - VALUE OF INTERPOLATION POLYNOMIAL.
C        YT( )    - INTERPOLATED VALUE OF SHEAR RATE AT EACH SHEAR
C                   STRESS ( SUBSCRIPTED BY L ).
C        YF       - FINAL INTERPOLATED VALUE OF SHEAR RATE.
C        KA       - FLAG - IF THE SHEAR STRESS DATA HAVE BEEN
C                   EXCEEDED IT IS SET TO 1.
      REAL X(30,30), Y(30), Z(30,30), YT(30), XR, YR, YP, YF, XZ
      INTEGER JX(30), JY, KA, I, L, L1, L2, K, K1, K2, IK, JK, IL
     1 , JL, JXA
      KA=0
C        FIND LOCATION OF INPUT SHEAR STRESS IN DATA.
      DO 140 I=1,JY
      L=I
 140  IF (YR.LT.Y(I))GO TO 141
C        DATA IS EXCEEDED.
      KA=1
      WRITE(6,100)
 100  FORMAT(1H ,14X,30HSHEAR STRESS DATA IS EXCEEDED.)
      RETURN
C        DEFINE INTERPOLATION RANGE.
 141  L1=L-2
      L2=L+1
C        IF AT BOTTOM END OF DATA, LINEARIZE INTERPOLATION WITH
C        RESPECT TO SHEAR STRESS.
      IF (L1.GT.0) GO TO 142
      L1=1
      L2=2
```

```
C        IF AT TOP OF DATA, LINEARIZE INTERPOLATION WITH RESPECT
C        TO SHEAR STRESS.
 142  IF (L2.LE.JY) GO TO 143
      L1=JY-1
      L2=JY
C        BEGIN CALCULATION OF SHEAR RATE AT EACH SHEAR STRESS
C        IN THE INTERPOLATION RANGE.
 143  DO 150 L=L1,L2
      JXA=JX(L)
C        FIND LOCATION OF INPUT TIME IN DATA AT SHEAR STRESS
C        CORRESPONDING TO L.
      DO 144 I=1,JXA
      K=I
 144  IF (XR.LT.X(I,L)) GO TO 145
C        UPPER END OF TIME CORRESPONDS TO LIMITING VALUE (I.E.
C        INFINITY).
      XR=X(K,L)
C        DEFINE INTERPOLATION RANGE OF TIME.
 145  K1=K-2
      K2=K+1
C        LINEARIZE AT BOTTOM OF TIME DATA.
      IF (K1.GE.1) GO TO 146
      K1=1
      K2=2
C        LINEARIZE AT TOP OF TIME DATA.
 146  IF (K2.LE.JXA) GO TO 147
      K1=JXA-1
      K2=JXA
C        CALCULATE INTERPOLATION POLYNOMIAL WITH RESPECT TO TIME
C        ( AT CONSTANT SHEAR STRESS ).
 147  YT(L)=0.00
      DO 149 IK=K1,K2
      YP=1.00
      DO 148 JK=K1,K2
      IF (JK.EQ.IK) GO TO 148
      XZ=(XR-X(JK,L))/(X(IK,L)-X(JK,L))
      YP=YP*XZ
 148  CONTINUE
 149  YT(L)=YT(L)+YP*Z(IK,L)
 150  CONTINUE
C        CALCULATE INTERPOLATION POLYNOMIAL FOR SHEAR RATE AT
C        CONSTANT (REQUIRED) TIME.
      YF=0.00
      DO 152 IL=L1,L2
      YP=1.00
      DO 151 JL=L1,L2
      IF (JL.EQ.IL) GO TO 151
      XZ=(YR-Y(JL))/(Y(IL)-Y(JL))
      YP=YP*XZ
 151  CONTINUE
C        YF IS THE REQUIRED VALUE OF SHEAR RATE.
 152  YF=YF+YP*YT(IL)
```

```
      RETURN
      END
```

```
      SUBROUTINE LENGTH (TAGE, TINIT, JT, JS, GT, GTOW, GDVDR,
     1 TOWMIN, EPS1, EPS2, EPS3, EPS4, EPS5, EPS6, DELTAL, QG, N,
     2 RF, NJ, TOW, PL, JW, EPS, Q, XL, TJ, RJ, VJ, TT, NT, N2,
     3 JJT, REN, NMAX)
C    'LENGTH' IS CALLED BY 'TIME'.
C    'LENGTH' CALCULATES FLOW PROFILES AND WALL SHEAR STRESS
C    ALONG THE PIPE AT MAXIMUM INPUT FLOW DURATION.  BASED ON
C    SHEAR STRESS ACCURACY, THE DISTANCES BETWEEN LONGITUDINAL
C    POSITIONS VARY.
C
C     LIST OF SYMBOLS
C        TW       - WALL SHEAR STRESS (LB/SQ FT).
C        TB       - STORED SHEAR STRESS (LB/SQ FT).
C        TA       - STORED SHEAR STRESS (LB/SQ FT).
C        TOW( )   - VECTOR STORAGE OF TW.
C        PL( )  - VECTOR STORAGE OF LONGITUDINAL POINTS.
C        XL       - PIPE LENGTH (FT).
C        RF       - RADIUS OF PIPE (FT).
C        J        - INTEGER DEFINING ABOVE VECTOR.
C        NJ       - LIMIT OF J - NUMBER OF POSITIONS IN PIPE.
C        NZ       - NUMBER OF QUADRATURE LOCATIONS ACROSS PIPE
C                   RADIUS.
C        T( )     - VECTOR CONTAINING FLUID AGES AT QUADRATURE
C                   POINTS (E.G. AT J).
C        TP( )    - VECTOR CONTAINING FLUID AGES AT QUADRATURE
C                   POINTS (E.G. AT J-1).
C        TR( )    - VECTOR CONTAINING FLUID AGES AT QUADRATURE
C                   POINTS (E.G. J-2).
C        VZ( )    - VELOCITY VECTOR AT QUADRATURE POINTS (E.G. J).
C        VP( )    - VELOCITY VECTOR AT QUADRATURE
C                   POINTS (E.G. J-1).
C        VR( )    - VELOCITY VECTOR AT QUADRATURE
C                   POINTS (E.G. J-2).
C        DELTAL   - LONGITUDINAL INCREMENT LENGTH.
C        R1( )    - RADIAL POSITIONS (MEASURED FROM WALL) OF
C                   STREAMLINES (AT J).
C        RP( )    - RADIAL POSITIONS (MEASURED FROM WALL) OF
C                   STREAMLINES (AT J-1).
C        V1( )    - STREAMLINE VELOCITY (AT J).
C        VVP( )   - STREAMLINE VELOCITY (AT J-1).
C        TT( )    - DURATIONS OF FLOW REQUIRED.
C        NT       - NUMBER OF FLOW DURATIONS.
C        TJ( , ) - STARTING AGES FOR CALCULATION AT OTHER FLOW
C                   DURATIONS.
C        VJ( , ) - STARTING VELOCITIES FOR SUBSEQUENT
C                   CALCULATIONS.
C        RJ( , ) - STREAMLINE RADIAL POSITIONS FOR COMENCEMENT OF
C                   SUBSEQUENT FLOW DURATIONS.
C        JJT( )   - INTEGER LOCATION OF CALCULATIONAL STARTING
C                   POSITION.
      REAL TP(100), TR(100), T(100), PL(50), TOW(50), TW, TB, TA,
```

```
     1 P1, EPS, DELTAL, V1(35), R1(35), Q(35), GTOW(30), GT(30,30
     2 ), GDVDR(30,30), EPS1, EPS2, EPS3, EPS4, EPS5, EPS6, RZ,
     3 TINIT, TAGE, RF, TOWMIN, QG, REN, VP(100), XL, VR(100),
     4 VZ(100), RP(35), VVP(35), TT(10), TJ(100,10), RJ(35,10),
     5 VJ(100,10)
      INTEGER KR, N, I, J, KL, KJ, JS, JT(30), KA, KOT, NMAX, NP,
     1 JW, KB, N1, N2, JJT(10), NT, NNT, NJ, NZ, II
C         INITIALIZE SELECTION OF LENGTH POSITIONS.
      N2=1
      NNT=NT-1
      T(1)=TINIT
      PL(1)=0.00
      KOT=0
C         CALCULATE INITIAL PROFILE AND PRINT IT OUT.
      J=1
      CALL INITPR (V1, R1, T, TW, RZ, RF, N, JT, JS, GT, GTOW,
     1 GDVDR, KOT, Q, TOWMIN, KA, QG, EPS1, EPS2, NMAX, VZ)
      NP=N+1
      IF (KA.EQ.1) RETURN
      IF (JW.GT.0) CALL WRITE1 (TAGE, RF, TW, J, PL, N, R1, V1,
     1 Q, T, REN, KOT, RZ)
      TOW(1)=TW
C         INITIALIZE COUNTERS.
      J=2
      KB=1
      KR=0
      KL=0
      KJ=0
C         STORE VECTORS FOR USE AFTER PROCEDING TWO POSITIONS.
      NZ=3*N
 300  DO 301 I=1,NZ
      VR(I)=VZ(I)
 301  TR(I)=T(I)
C         STORE VECTORS FOR USE AFTER PROCEDING ONE POSITION.
 302  DO 303 I=1,NZ
      VP(I)=VZ(I)
 303  TP(I)=T(I)
C         DEFINE POSITION ALONG PIPE.
 304  PL(J)=PL(J-1)+DELTAL
C         CHECK TO SEE IF TOTAL LENGTH HAS BEEN ENCOUNTERED.
      IF (PL(J).LT.(XL-0.001)) GO TO 315
      KB=0
      PL(J)=XL
 315  CONTINUE
C         CALCULATE PROFILE AT DEFINED POSITION.
      CALL OPTIM (TAGE, TINIT, JT, JS, GT, GTOW, GDVDR, EPS3,
     1 EPS4, EPS5, QG, Q, RF, R1, VP, TW, PL, J, T, TP, KR, N,
     2 V1, EPS6, VZ)
C         IF MINIMUM LENGTH IS KNOWN, GO TO 310.
      IF (KJ.GT.0) GO TO 310
C         IF KL = 0, PREPARE TO CUT TEST LENGTH IN TWO.
      IF (KL.GT.0) GO TO 306
```

```
C        HALVE INCREMENT, STORE SHEAR STRESS.
 305  TA=TW
      DELTAL=DELTAL/2.0
      KL=1
      TW=TOW(1)
      GO TO 304
C        IF KL = 1, FIRST SEGMENT OF TEST LENGTH HAS BEEN
C        CALCULATED.
 306  IF (KL.GT.1) GO TO 307
C        STORE QUANTITIES FOR PRINT OUT.
      DO 18 I=1,NP
      RP(I)=R1(I)
  18  VVP(I)=V1(I)
      TB=TW
      KL=2
      J=3
      GO TO 302
C        CALCULATE CHANGE IN SHEAR STRESS OVER TEST LENGTH
C        FOR HALF-STEPS.
 307  IF ((ABS(TW-TA)/TW).LT.EPS) GO TO 309
C        ERROR IS GREATER THAN EPS, USE PRESENT INCREMENT LENGTH
C        AS TEST SIZE.
      J=2
      DO 308 I=1,NZ
      VP(I)=VR(I)
 308  TP(I)=TR(I)
      GO TO 305
C        ERROR IS LESS THAN EPS, MINIMUM LENGTH IS FOUND AND
C        INCREMENT LENGTH IS DOUBLED.
 309  DELTAL=DELTAL*2.00
      TOW(2)=TB
      TOW(3)=TW
      J=2
C        CHECK FOR CALCULATION STARTING POINT OF OTHER FLOW
C        DURATIONS AFTER FIRST PROFILE.
      N1=N2
      DO 316 II=N1,NNT
      IF (TP(1).LT.(TT(II)+TINIT)) GO TO 316
      JJT(II)=J
      DO 317 I=1,NZ
      TJ(I,II)=TR(I)
 317  VJ(I,II)=VR(I)
      DO 322 I=1,NP
 322  RJ(I,II)=RP(I)
      N2=II+1
 316  CONTINUE
C        PRINT OUT SECOND PROFILE.
      IF (JW.GT.0) CALL WRITE1 (TAGE, RF, TB, J, PL, N, RP, VVP,
     1 Q, TP, REN , KOT, RZ)
      J=3
C        CHECK FOR CALCULATION STARTING POINT OF OTHER
C        FLOW DURATIONS AFTER SECOND PROFILE.
```

```
      N1=N2
      DO 318 II=N1,NNT
      IF (T(1).LT.(TT(II)+TINIT)) GO TO 318
      JJT(II)=J
      DO 319 I=1,NZ
      TJ(I,II)=TP(I)
  319 VJ(I,II)=VP(I)
      DO 323 I=1,NP
  323 RJ(I,II)=R1(I)
      N2=II+1
  318 CONTINUE
C        PRINT THIRD PROFILE.
      IF (JW.GT.0) CALL WRITE1 (TAGE, RF, TW, J, PL, N, R1, V1,
     1 Q, T, REN, KOT, RZ)
      KJ=1
      KL=0
      J=4
      GO TO 300
C        IF END OF PIPE HAS BEEN REACHED, GO TO 314.
  310 IF (KR.GT.0) GO TO 314
C        IF FLUID HAS COMPLETELY AGED (ACCORDING TO FLOW
C           DURATION), GO TO 314.
      IF (KB.LT.1) GO TO 314
C        IF INCREMENT HAS BEEN DOUBLED, GO TO 313.
      IF (KL.GT.1) GO TO 313
C        STORE SHEAR STRESS.
      TOW(J)=TW
C        CHECK FOR CALCULATION STARTING POINT OF OTHER
C        FLOW DURATIONS.
      IF (N2.GT.NNT) GO TO 325
      N1=N2
      DO 320 II=N1,NNT
      IF (T(1).LT.(TT(II)+TINIT)) GO TO 320
      JJT(II)=J
      DO 321 I=1,NZ
      TJ(I,II)=TP(I)
  321 VJ(I,II)=VP(I)
      DO 324 I=1,NP
  324 RJ(I,II)=R1(I)
      N2=II+1
  320 CONTINUE
  325 CONTINUE
C        PRINT OUT PROFILE.
      IF (JW.GT.0) CALL WRITE1 (TAGE, RF, TW, J, PL, N, R1, V1,
     1 Q, T, REN, KOT, RZ)
C        IF KL = 0, FIRST SEGMENT IS CALCULATED.
      IF (KL.GT.0) GO TO 311
C        PREPARE TO CALCULATE SECOND SEGMENT.
      J=J+1
      KL=1
      GO TO 302
C        SECOND SEGMENT IS CALCULATED.
```

```
 311  P1=PL(J-1)
C        DOUBLE INCREMENT SIZE FOR CONVERGENCE TEST.
      DELTAL=DELTAL*2.00
      DO 312 I=1,NZ
C        REDEFINE STORED VECTORS.
      VP(I)=VR(I)
 312  TP(I)=TR(I)
      J=J-1
      KL=2
      GO TO 304
 313  PL(J)=P1
      J=J+2
      KL=0
C        CHECK SHEAR STRESS ERROR AFTER CALCULATION AT TWO
C        INCREMENT SIZES.
      IF (ABS((TOW(J-1)-TW)/TOW(J-1)).LT.EPS) GO TO 300
C        RETAIN SMALLER INCREMENT.
      DELTAL=DELTAL/2.00
      GO TO 300
 314  NJ=J
      TOW(J)=TW
C        PRINT OUT FINAL PROFILE.
      IF (JW.GT.0) CALL WRITE1 (TAGE, RF, TW, J, PL, N, R1, V1,
     1 Q, T, REN, KOT, RZ)
C        IF END OF PIPE WAS NOT REACHED, DEFINE THIS POINT.
      IF (PL(NJ).GE.(XL-0.0001)) RETURN
      NJ=NJ+1
      PL(NJ)=XL
      TOW(NJ)=TOW(NJ-1)
      RETURN
      END
```

```
      SUBROUTINE OPTIM (TAGE, TINIT, JT, JS, GT, GTOW, GDVDR,
     1EPS3, EPS4, EPS5, QG, Q, RF, R1, VP, TW, PL, J, T, TP, KR,
     2 N, V1, EPS6, VR)
C   'OPTIM' IS CALLED BY 'LENGTH' AND BY 'TIME'
C   'OPTIM' CONVERGES WALL SHEAR STRESS, FLUID AGES, RADII, AND
C   VELOCITIES, GIVEN THE PREVIOUS AGE AND VELOCITY PROFILES.
C
C     LIST OF SYMBOLS
C        PL( )    - VECTOR MEASURING POSITION ALONG PIPE (FT).
C        J        - INTEGER SPECIFYING POSITION.
C        TP( )    - PREVIOUS AGE PROFILE (MIN) AT QUADRATURE
C                   LOCATIONS.
C        VP( )    - PREVIOUS VELOCITY PROFILE (FT/SEC) AT
C                   QUADRATURE LOCATIONS.
C        R1( )    - RADIAL POSITION (MEASURED FROM WALL)
C                   AT EDGES OF STREAMLINES.
C        T( )     - AGE PROFILE AT PRESENT PIPE POSITION.
C        TA( )    - PREVIOUS TRIAL VALUE OF T( ).
C        VR( )    - VELOCITY PROFILE AT PRESENT PIPE POSITION.
C        QG       - GIVEN VALUE OF FLOW RATE (CU FT/SEC).
C        QE       - ERROR IN CALCULATED FLOW RATE.
C        QO       - INITIAL VALUE OF QE.
C        TW       - WALL SHEAR STRESS (LB/SQ FT).
C        TO       - INITIAL VALUE OF TW.
C        TB       - PREVIOUS CONVERGENT VALUE OF TW.
C        TAGE     - DURATION OF FLOW (MIN).
C        TINIT    - AGE OF FLUID AT PIPE ENTRANCE.
      REAL GTOW(30), GT(30,30), GDVDR(30,30), Q(35), T(100),
     1 TP(100), R1(35), VP(100), PL(50), V1(35), Q2(35), QG,
     2 RF, C1, TAGE, QE, QO, TW, TB, EPS3, EPS4, EPS5, EPS6, TR,
     3 VR(100), TA(100), TINIT
      INTEGER N, JS, JT(30), KR, J, NP, NN, I
C        INITIALIZE FOR ITERATION AT POSITION J.
      C1=(PL(J)-PL(J-1))/60.
      NP=N+1
      NN=3*N
      TB=0.00
C        DEFINE NEW AGES FROM PREVIOUS PROFILE.
      DO 111 I=1,NN
      T(I)=C1/VP(I)+TP(I)
      IF (TP(I).GT.(TAGE+1.0E-07)) GO TO 111
      IF (TP(I).GT.(TAGE-1.0E-07)) T(I)=TAGE
 111  CONTINUE
C        CALCULATE FLOW RATE ERROR FROM PREVIOUS VALUE OF SHEAR
C        STRESS.
 112  CALL SUBINT (JT, JS, GT, GTOW, GDVDR, T, TW, N, RF, R1, V1,
     1 QG, QO, Q2, VR)
      TO=TW
C        SELECT NEW VALUE OF SHEAR STRESS BASED ON ERROR.
      TW=TW*(1.0+QO*0.1)
C        SHEAR STRESS CANNOT BE NEGATIVE.
```

```
      IF (TW.LT.0.00) TW=0.00
C        CALCULATE FLOW RATE ERROR.
 113  CALL SUBINT (JT, JS, GT, GTOW, GDVDR, T, TW, N, RF, R1, V1,
     1 QG, QE, Q2, VR)
C        IF ERROR IS TOLERABLE GO TO 114.
      IF (ABS(QE).LT.EPS5) GO TO 114
C        CALCULATE NEW SHEAR STRESS TRIAL VIA REGULI-FALSI.
      TW=TW-QE*(TW-TO)/(QE-QO)
      GO TO 113
C        RECOMPUTE PRESENT AGE PROFILE.
 114  CONTINUE
      DO 115 I=1,NN
      TA(I)=T(I)
      T(I)=C1*2./(VR(I)+VP(I))+TP(I)
C        THE AGE PROFILE CANNOT EXCEED FLOW AGE.
      IF(TP(I).GT.(TAGE+1.0E-07))GO TO 118
      IF (TP(I).GT.(TAGE-1.0E-07)) GO TO 119
      GO TO 118
 119  T(I)=TAGE
      GO TO 115
 118  IF(T(I).LT.(TAGE+TINIT))GO TO 115
      IF (I.EQ.NN) KR=1
      T(I)=TAGE
 115  CONTINUE
C        IF AGE AT THE WALL IS NOT CONVERGED, GO TO 112.
      IF ((ABS(TA(1)-T(1))/T(1)).GT.EPS4) GO TO 112
C        HAS SHEAR STRESS CONVERGED FOR A CHANGE IN RADII.
      IF ((ABS(TW-TB)/TW).LT.EPS6) GO TO 117
      KR=0
      TB=TW
C        CHANGE RADII TO AGREE WITH INCREMENTAL FLOW RATES.
      CALL RADII (V1, R1, N, RF, Q, EPS3)
      GO TO 112
C        DEFINE AGE VECTOR AT LAST VALUE OF SHEAR STRESS.
 117  DO 116 I=1,NN
 116  T(I)=TA(I)
      RETURN
      END
```

```
      SUBROUTINE RADII (V1, R1, N, RF, Q, EPS)
C   'RADII' IS CALLED BY 'OPTIM'.
C   'RADII' SHIFTS STREAMLINE RADII SO THAT THE INCREMENTAL FLOW
C   RATES AGREE WITH PREVIOUSLY DEFINED VALUES USING GOLDEN
C   INTERVAL ITERATION AND REGULI-FALSI INTERATION.
C
C     LIST OF SYMBOLS
C         V1( )   - VELOCITY OF STREAMLINES (FT/SEC).
C         R1( )   - RADIAL POSITION OF STREAMLINES (MEASURED FROM
C                   WALL).
C         NP      - NUMBER OF STREAMLINES.
C         N       - NUMBER OF INCREMENTS.
C         R( )    - NEWLY CALCULATED RADII (FT).
C         RA( )   - OLD VALUES OF RADIUS (FT).
C         Q( )    - INCREMENTAL FLOW RATES (CU FT/SEC).
C         RF      - RADIUS OF PIPE (FT).
C         A       - TRIAL RADIUS (FT).
C         FQ      - INCREMENTAL FLOW RATE AT A (CU FT/SEC).
C         QA      - ERROR IN FLOW RATE ASSOCIATED WITH A.
C         QB      - PREVIOUS VALUE OF QA.
C         EPS     - MAXIMUM ALLOWABLE VALUE OF QA THAT TERMINATES
C                   A SEARCH FOR A.
C         B1      - LOWER LIMIT OF A FOR GOLDEN INTERVAL SEARCH.
C         B2      - UPPER LIMIT OF A FOR GOLDEN INTERVAL SEARCH.
C         O       - LOWER IIMIT OF A FOR REGULI-FALSI SEARCH.
C         QO      - VALUE OF QA AT O.
      REAL V1(35), R1(35), RA(35), R(35), Q(35), RF, A, QA, QO,
     1 EPS, FQ, O, B1, B2, SB1, SB2, QB1, QB2, QB, RZ
      INTEGER I, I1, N, N1, NP, M
C         DEFINE LIMITS AND CHANGE RADIAL POSITIONS TO RADII.
      NP=N+1
      R(NP)=0.00
      R(1)=RF
      QO=-1.00
      DO 10 I=1,NP
   10 RA(I)=RF-R1(I)
C         INITIALIZE GOLDEN INTERVAL SEARCH FOR INCREMENT NEAREST
C         THE PIPE WALL
      I=1
      QA=0.00
      M=0
      I1=I+1
      RZ=R(I)
      B1=RA(I+2)
      B2=R(I)
C         SELECT TRIAL VALUE OF A.
    9 CALL GOLDIT (M, B1, B2, A, QA, SB1, SB2, QB1, QB2)
C         CALCULATE INCREMENTAL FLOW RATE FROM A TO RZ.
      CALL INTCON (V1, RA, NP, FQ, A, RZ)
      QB=QA
C         CALCULATE ERROR IN INCREMENTAL FLOW RATE.
```

```
      QA=ABS(FQ-Q(I))/Q(I)
C        CHECK TO SEE IF THERE HAS BEEN A CHANGE IN FLOW RATE
C        ERROR, I.E. IF EPS IS SMALLER THAN CAN BE TOLERATED.
      IF (ABS(QA-QB).GT.1.0E-30) GO TO 8
      WRITE(6,7) QA, EPS
    7 FORMAT(1H ,14X,5HQA = ,E15.8,13HWHILE EPS3 = ,E15.8)
      QA=1.0E-30
C        IF FLOW RATE ERROR IS TOO LARGE OBTAIN NEW TRIAL VALUE
C        FROM 'GOLDIT'.
    8 IF (QA.GT.EPS) GO TO 9
C        STORE NEW RADIUS IN VECTOR R( ).
   15 R(I1)=A
C        REGULI FALSI SEARCH FOR THE REMAINING RADII.
      N1=N-1
      DO 12 I=2,N1
C        INITIALIZE FOR INITAL TRIAL VALUE.
      I1=I+1
      O=R(I)
      A=RA(I1)
      GO TO 14
C        NEW TRIAL VALUE FROM REGULI-FALSI CALCULATION.
   11 CONTINUE
      A=A-QA*(A-O)/(QA-QO)
C        CALCULATE INCREMENTAL FLOW RATE FROM A TO O.
   14 CALL INTCON (V1, RA, NP, FQ, A, O)
C        CALCULATE ERROR IN FLOW RATE.
      QA=(FQ-Q(I))/Q(I)
C        IF QA LESS THAN EPS STORE A AND DO NEXT VALUE.
      IF (ABS(QA).GT.EPS) GO TO 11
   12 R(I1)=A
C        REDEFINE RADIAL POSITION VECTOR.
      DO 13 I=2,N
   13 R1(I)=RF-R(I)
      RETURN
      END
```

```
      SUBROUTINE SINT (JT, JS, GT, GTOW, GDVDR, T, TW, KA, R1, I,
     1 VEL, RF)
C    'SINT' IS CALLED BY 'INITPR' AND BY 'SUBINT'.
C    'SINT' CALCULATES THE INCREASE IN VELOCITY ACROSS AN INCRE-
C    MENT BY INTEGRATING SHEAR RATE ACCORDING TO GAUSSIAN THREE-
C    POINT QUADRATURE.  THE INCREASE IN VELOCITY IS USED IN CON-
C    STRUCTION OF THE VELOCITY PROFILE.
C
C     LIST OF SYMBOLS
C        GTOW( )    - SHEAR STRESS DATA.
C        GT( , )    - TIME DATA.
C        GDVDR( , )- SHEAR RATE DATA.
C        JT( )      - EXTENT OF TIME AND SHEAR RATE POINTS.
C        JS         - EXTENT OF JT (AT EACH SHEAR STRESS) AND OF
C                     SHEAR STRESS POINTS.
C        I        - INTEGER STREAMLINE NUMBER (NUMBERED FROM PIPE
C                   WALL).
C        R1( )    - RADIAL POSITION OF STREAMLINE (MEASURED FROM
C                   WALL).
C        BB       - OUTER EDGE OF INCREMENT (FROM WALL).
C        AA       - INNER EDGE OF INCREMENT (FROM WALL).
C        RF       - RADIUS OF PIPE (FT).
C        M        - QUADRATURE POINT NUMBER (1 TO 3).
C        Z        - QUADRATURE POINT LOCATION (-1 TO +1) CORRES-
C                   PONDING TO  VALUE OF M.
C        H        - INTEGRAL WEIGHTING FACTOR CORRESPONDING TO M.
C        F        - RADIAL POSITION CORESSPONDING TO Z
C        TOWR     - SHEAR STRESS AT F.
C        T( )     - STORED AGES AT QUADRATURE LOCATION IN THE PIPE.
C        TR       - FLUID AGE AT F
C        YF       - SHEAR RATE AT F.
C        SG       - INTEGRAL ON RANGE -1 TO +1 (1/SEC).
C        VEL      - INTEGRAL ACROSS INCREMENT (FT/SEC), OR
C                   INCREASE IN VELOCITY ACROSS INCREMENT.
      REAL R1(35), GTOW(30), GT(30,30), GDVDR(30,30), SG, Z, H,
     1 F, TOWR, VEL, BB, AA, RF, YF, TR, TW, T(100)
      INTEGER M, I, KA, JS, JT(30), II
C        SPECIFY INCREMENT BOUNDS AND INITIALIZE INTEGRATION.
      SG=0.00
      BB=R1(I)
      AA=R1(I-1)
      M=1
C        SELECT Z AND H CORRESPONDING TO M.
  130 GO TO (131,132,133),M
  131 Z=-0.77459667
      H=0.55555555
      GO TO 134
  132 Z=0.00
      H=0.88888888
      GO TO 134
  133 Z=+0.77459667
```

```
      H=0.55555555
C        CONVERT Z TO RADIAL POSITION F.
 134  F=((BB-AA)*Z+AA+BB)/2.
C        CALCULATE SHEAR STRESS AT F.
      TOWR=(RF-F)*TW/RF
C        DEFINE TIME AT F FROM STORED AGE.
      II=3*I-6+M
      TR=T(II)
C        CLACULATE SHEAR RATE.
      CALL INTERB (JT, JS, GT, GTOW, GDVDR, TR, TOWR*1000., YF,
     1 KA)
C        IF SHEAR STRESS DATA IS EXCEEDED RETURN.
      IF (KA.EQ.1) RETURN
C        ADD INTEGRAL AT F.
      SG=SG+H*YF
C        INCREASE M AND CHECK FOR COMPLETION OF INTEGRATION.
      M=M+1
      IF (M.LE.3) GO TO 130
C        CONVERT INTEGRAL TO INCREASE IN VELOCITY.
      VEL=(BB-AA)*SG/2.
      RETURN
      END
```

```
      SUBROUTINE SUBINT (JT, JS, GT, GTOW, GDVDR, T, TW, N, RF,
     1 R1, V1, QG, QE, Q2, VZ)
C    'SUBINT' IS CALLED BY 'OPTIM'.
C    'SUBINT' CALCULATES THE VELOCITY PROFILE AND INCREMENTAL FLOW
C    RATES FROM GIVEN RADIAL POSITIONS, STREAMLINE AGES, AND WALL
C    SHEAR STRESS.  THE ERROR IN TOTAL FLOW RATE IS CALCULATED.
C
C      LIST OF SYMBOLS
C         GTOW( )    - SHEAR STRESS DATA.
C         GT( , )    - TIME DATA.
C         GDVDR( , )- SHEAR RATE DATA.
C         JT( )     - EXTENT OF TIME AND SHEAR RATE POINTS.
C         JS        - EXTENT OF JT (AT EACH SHEAR STRESS) AND OF
C                     SHEAR STRESS.
C         RF       - RADIUS OF PIPE (FT).
C         R1( )    - RADIAL POSITIONS OF STREAMLINES (FROM PIPE
C                    WALL) (FT).
C         RA( )    - RADII OF STREAMLINES (FT).
C         T( )     - FLUID AGES AT QUADRATURE LOCATIONS (MIN).
C         NP       - NUMBER OF STREAMLINES.
C         N        - NUMBER OF INCREMENTS.
C         I        - INTEGER NUMBER OF INCREMENT BOUNDED BY STREAM-
C                    LINES I AND I+1 (NUMBERED FROM THE WALL).
C         V1( )    - VELOCITY POINTS (FT/SEC).
C         VEL      - INCREMENTAL INCREASE IN VELOCITY (FT/SEC).
C         Q2( )    - INCREMENTAL FLOW RATES (CU FT/SEC).
C         QSUM     - CALCULATED TOTAL FLOW RATE (CU FT/SEC).
C         QG       - GIVEN TOTAL FLOW RATE.
C         QE       - ERROR ASSOCIATED WITH QSUM.
      REAL TW, R1(35), RA(35), T(100), RF, QSUM, FQ, QE, VEL, QG,
     1 V1(35), Q2(35), GTOW(30), GT(30,30), GDVDR(30,30), VZ(100)
      INTEGER I, N, NP, JS, JT(30), KA
      NP=N+1
C         DEFINE RADII FROM RADIAL POSITIONS.
      DO 21 I=1,NP
   21 RA(I)=RF-R1(I)
C         CALCULATE VELOCITY PROFILE.
      V1(1)=0.00
      DO 22 I=2,NP
      CALL SINT (JT, JS, GT, GTOW, GDVDR, T, TW, KA, R1, I, VEL,
     1 RF)
C         INCREMENTAL INCREASE IN VELOCITY IS ADDED TO VELOCITY AT
C         FRONT OF INCREMENT.
   22 V1(I)=V1(I-1)+VEL
C         CALCULATE INCREMENTAL FLOW RATES.
      QSUM=0.00
      DO 23 I=1,N
      CALL INTEGR (V1, RA, I, NP, FQ, VZ)
C         STORE INCREMENTAL FLOW RATE.
      Q2(I)=FQ
C         SUM FOR TOTAL CALCULATED FLOW RATE.
```

```
   23  QSUM=QSUM+FQ
C        FIND ERROR IN FLOW RATE.
       QE=(QG-QSUM)/QG
       RETURN
       END
```

```
      SUBROUTINE TIME (TINIT, JS, JT, GTOW, GT, GDVDR, DELTAL,
     1 QG, N, NMAX, TOWMIN, RF, EPS1, EPS2, EPS3, EPS4, EPS5,
     2 EPS6, REN, JW1, JW2, TT, NT, EPS7, XL, RR)
C    'TIME' IS CALLED BY THE CONTROL PROGRAM.
C    'TIME' CALCULATES ACCUMULATED PRESSURE DROP, LONGITUDINAL
C    SHEAR STRESS PROFILES FOR SUB-LIMITING DURATION OF FLOW
C    CONDITIONS, AND ALL PROFILES IN WHICH A PLUG CONDITION
C    IS PRESENT.
C
C      LIST OF SYMBOLS
C         J        - INTEGER LOCATING POSITION ALONG PIPE.
C         TOW( )   - VECTOR OF WALL SHEAR STRESSES ALONG
C                    PIPE (LB/SQ FT).
C         PL( )    - DISTANCE FROM THE PIPE ENTRANCE OF TOW(J) (FT).
C         XL       - LENGTH OF PIPE (FT).
C         NJ       - UPPER LIMIT OF J.
C         TT( )    - VALUES OF FLOW DURATIONS TO RECALCULATE (MIN).
C         NT       - NUMBER OF THESE VALUES.
C         IT       - SUBSCRIPT ON TT( ).
C         TAGE     - VALUE OF TT(IT).
C         JJT( )   - INTEGER POSITION OF PROFILE AT WHICH THESE
C                    CALCULATIONS BEGIN.
C         N        - NUMBER OF INCREMENTS.
C         NP       - NUMBER OF STREAMLINES.
C         NN       - NUMBER OF QUADRATURE LOCATIONS IN X-SECTION.
C         TJ( , )  - DEFINES PREVIOUS PROFILE AGES AT QUADRATURE
C                    POINTS FOR INITIALIZATION OF CALCULATION.
C         VJ( , )  - DEFINES PREVIOUS PROFILE VELOCITIES AT
C                    QUADRATURE POINTS FOR INITIALIZATION.
C         RJ( , )  - PREVIOUS PROFILE STREAMLINE POSITIONS
C                    FOR INITIALIZATION.
C         TP( )    - PREVIOUS PROFILE AGES.
C         VP( )    - PREVIOUS PROFILE VELOCITIES.
C         R1( )    - STREAMLINE RADIAL POSITIONS.
C         T( )     - PRESENT PROFILE AGES.
C         VZ( )    - PRESENT PROFILE VELOCITIES.
C         KOT,KOJ  - INTEGER SPECIFYING GEL CONDITION,
C                    EQUALS 0 - NO GEL, EQUALS 1 - RADIUS OF GEL
C                    IS SPECIFIED, EQUALS 2 - RADIUS OF GEL MUST
C                    BE FOUND.
C         PP( )    - POSITION ALONG PIPE (FT).
C         DP( )    - TOTAL PRESSURE DROP (LB/SQ IN) UP TO PP( ).
C         JR( )    - NUMBER OF POINTS IN PP( ) VECTOR.
C         TW       - SHEAR STRESS.
C         TSAVE    - LIMITING VALUE OF SHEAR STRESS AT PIPE EXIT.
      REAL TAGE, TW, TSAVE, T(100), TOW(50), PL(50), TINIT,
     1 GTOW(30), GT(30,30), GDVDR(30,30), Q(35), R1(35), V1(35),
     2 RR, RF, TOWMIN, QG, EPS1, EPS2, EPS3, EPS4, EPS5, EPS6,
     3 EPS7, REN, DP(100), PP(100), TP(100), TT(10), VP(100), W
     4, DELTAL, XL, TWO, VZ(100), TJ(100,10), RJ(35,10), VJ(100,
     5 10), PSUM, Q2(35)
```

```
      INTEGER KOT, KA, N, J, I, NP, JS, JT(30), NMAX, NJ1, NJ,
     1 JJ, NT, JW1, JW2, IT, KOJ, N1, N2, JJT(10), JZ, KR, NZ, JR
C        DEFINE NON-GEL CONDITION.
      KOJ=0
      TWO=0.00
C        IF THERE IS NO GEL, GO TO 800.
      IF (TOWMIN.LE.1.0E-30) GO TO 800
C        DEFINE GEL CONDITION AT FLUID AGE OF ZERO.
      KOJ=1
      T(1)=0.00
C        IF PLUG RADIUS IS PREVIOUSLY DEFINED, GO TO 800.
      IF (RR.GT.1.0E-30) GO TO 800
C        CALCULATE PLUG RADIUS AND WALL SHEAR STRESS.
      KOT=2
      CALL INITPR (V1, R1, T, TW, RR, RF, N, JT, JS, GT, GTOW,
     1 GDVDR, KOT, Q, TOWMIN, KA, QG, EPS1, EPS2, NMAX,VZ)
      IF (KA.EQ.1) RETURN
      TWO=TW
C        PRINT OUT PROFILE.
      IF (JW1.GT.0) CALL WRITE1 (TAGE, RF, TW, J, PL, N, R1, V1,
     1 Q, T, REN, KOT, RR)
C        THE AGE OF FLOW IS THE FINAL PROGRAMMED DURATION.
 800  TAGE=TT(NT)
C        CALCULATE SHEAR STRESSES AND SELECT CALCULATIONAL
C        POINTS ALONG PIPE.
      CALL LENGTH (TAGE, TINIT, JT, JS, GT, GTOW, GDVDR, TOWMIN,
     1 EPS1, EPS2, EPS3, EPS4, EPS5, EPS6, DELTAL, QG, N, RF, NJ,
     2 TOW, PL, JW1, EPS7, Q, XL, TJ, RJ, VJ, TT, NT, N2, JJT,
     3 REN, NMAX)
      NZ=3*N
      N1=N2-1
      NP=N+1
C        IF A GEL EXISTS, THE CONSTANT AGE PROFILES NEAR EXIT
C        MUST BE RECALCULATED.
      IF (KOJ.LT.1) GO TO 825
      KOT=1
      T(1)=TAGE
      CALL INITPR (V1, R1, T, TW, RR, RF, N, JT, JS, GT, GTOW,
     1 GDVDR, KOT, Q2, TOWMIN, KA, QG, EPS1, EPS2, NMAX, VZ)
      IF (JW1.GT.0) CALL WRITE1 (TAGE, RF, TW, J, PL, N, R1, V1,
     1 Q2, T, REN, KOT, RR)
C        THE SHEAR STRESS IS THEN ASSIGNED.
      NJ1=NJ
      IF (JJT(NT).GT.0) NJ1=JJT(NT)
      DO 820 J=NJ1,NJ
 820  TOW(J)=TW
 825  IT=0
C        CALCULATE ACCUMULATIVE PRESSURE DROP USING
C        SIMPSON'S RULE.
 804  PP(1)=0.00
      DP(1)=0.00
      JR=NJ/2
```

```
      DO 805 J=2,JR
      JJ=2*J-1
      DP(J)=(PL(JJ)-PL(JJ-1))*(TOW(JJ)+4.*TOW(JJ-1)+TOW(JJ-2))/3.
     1 *2./(144.*RF)+DP(J-1)
  805 PP(J)=PL(JJ)
      JR=JR+1
      PP(JR)=XL
      PSUM=0.00
      DO 806 J=JJ,NJ
  806 PSUM=PSUM+TOW(J)
      W=NJ-JJ+1
      DP(JR)=PSUM/W*2./(144.*RF)*(PL(NJ)-PL(JJ))+DP(JR-1)
C        PRINT OUT PRESSURE DROP VERSUS LENGTH.
      IF (JW2.GT.0) CALL WRITE2( TAGE, PP, DP, JR )
C        IF ALL FLOW DURATIONS HAVE BEEN CALCULATED, RETURN
C        TO CONTROL PROGRAM.
      IF (IT.GE.N1) RETURN
C        SELECT A NEW FLOW DURATION.
      IT=IT+1
      TAGE=TT(IT)
C        IF FLOW AGE IS ZERO, GO TO 813.
      IF (TAGE.LE.1.0E-30) GO TO 813
C        FIND POINT IN PIPE WHERE CALCULATION BEGINS.
      JZ=JJT(IT)
      TW=TOW(JZ)
C        ASSIGN AGE, VELOCITY, AND RADIUS PROFILES AT PREVIOUS
C        LONGITUDINAL POINT.
      DO 814 I=1,NZ
      TP(I)=TJ(I,IT)
  814 VP(I)=VJ(I,IT)
      DO 821 I=1,NP
  821 R1(I)=RJ(I,IT)
      KR=0
C        CALCULATE UNTIL EITHER THE END OF THE PIPE, OR
C        COMPLETE AGING IS ACHIEVED.
      DO 810 J=JZ,NJ
      JJ=J
      CALL OPTIM (TAGE, TINIT, JT, JS, GT, GTOW, GDVDR, EPS3,
     1 EPS4, EPS5, QG, Q, RF, R1, VP, TW, PL, J, T, TP, KR, N,
     2 V1, EPS6, VZ)
C        PRINT OUT PROFILE.
      IF (JW1.GT.0) CALL WRITE1 (TAGE, RF, TW, J, PL, N, R1, V1,
     1 Q, T, REN, KOT, RR)
C        STORE AGES AND VELOCITIES FOR NEXT PROFILE CALCULATION.
      DO 815 I=1,NZ
      VP(I)=VZ(I)
  815 TP(I)=T(I)
C        IF AGE IS CONSTANT ACROSS PIPE X-SECTION, GO TO 818.
      IF (KR.GT.0) GO TO 818
C        STORE SHEAR STRESS.
  810 TOW(J)=TW
C        IF PLUG EXISTS, CALCULATE AND PRINT OUT PROFILE.
```

```
 811  IF (KOJ.LT.1) GO TO 818
      T(1)=TAGE
      KOT=KOJ
      CALL INITPR (V1, R1, T, TW, RR, RF, N, JT, JS, GT, GTOW,
     1 GDVDR, KOT, Q2, TOWMIN, KA, QG, EPS1, EPS2, NMAX, VZ)
      IF (JW1.GT.0) CALL WRITE1 (TAGE, RF, TW, J, PL, N, R1, V1,
     1 Q2, T, REN, KOT, RR)
C          DEFINE SHEAR STRESS OF REMAINING PIPE X-SECTIONS.
 818  TSAVE=TW
      DO 812 J=JJ,NJ
 812  TOW(J)=TSAVE
      GO TO 804
C          AT ZERO AGE, ALL POINTS HAVE SAME PRESSURE DROP.
 813  TW=TOW(1)
C          IF ENTERING AGE IS ZERO, GO TO 821 TO CALCULATE
C          SHEAR STRESS.
      IF (TINIT.GT.1.0E-07) GO TO 822
C          IF GEL EXISTS, CALCULATE SHEAR STRESS.
      IF (KOJ.LT.1) GO TO 819
      IF (TWO.LT.1.0E-30) GO TO 822
      TW=TWO
      GO TO 819
 822  T(1)=0.00
      KOT=KOJ
      CALL INITPR (V1, R1, T, TW, RR, RF, N, JT, JS, GT, GTOW,
     1 GDVDR, KOT, Q2, TOWMIN, KA, QG, EPS1, EPS2, NMAX, VZ)
      J=1
      IF (JW1.GT.0) CALL WRITE1 (TAGE, RF, TW, J, PL, N, R1, V1,
     1 Q2, T, REN, KOT, RR)
C          ASSIGN SHEAR STRESS TO ALL VECTOR POINTS.
 819  DO 817 J=1,NJ
 817  TOW(J)=TW
      GO TO 804
      END
```

```
      SUBROUTINE WRITE1 (TAGE, RF, TW, J, PL, N, R1, V1, Q, T,
     1 REC, KOT, RR)
C   'WRITE1' IS CALLED BY 'LENGTH' AND BY 'TIME'.
C   'WRITE1' PRINTS OUT THE PERTINENT INFORMATION AT EACH PIPE
C   LOCATION.
C
C     LIST OF SYMBOLS
C        J       - INTEGER ASSOCIATED WITH POSITION IN PIPE.
C        PL( )   - ITS DISTANCE FROM THE ENTRANCE, FT.
C        TW      - SHEAR STRESS, LB/SQ FT.
C        DELP    - PRESSURE DROP PER FOOT, LB/SQ IN/FT.
C        RR      - WIDTH OF NON PLUG SECTION IF PLUG EXISTS, FT.
C        DE      - RADIUS OF PLUG, FT.
C        RF      - RADIUS OF PIPE, FT.
C        I       - INTEGER SPECIFYING INCREMENT NUMBER, STARTING
C                  FROM THE WALL.
C        R1( )   - DISTANCE OF STREAMLINE FROM WALL, FT.
C        R( )    - RADIUS OF STREAMLINE, FT.
C        V1( )   - VELOCITY AT R( ), FT/SEC.
C        Q( )    - INCREMENTAL FLOW RATE, CU FT/SEC.
C        T( )    - AGE DISTRIBUTION8 STARTING FROM WALL, MIN.
C        TAGE    - DURATION OF FLOW, MIN.
C        REC     - CONSTANT FOR REYNOLDS NUMBER (SQ FT/LB).
C        REN     - REYNOLDS NUMBER.
      REAL TAGE, RF, TW, PL(50), R1(35), R(35), V1(35), Q(35),
     1 T(100), REN, RR, DELP, DE, REC
      INTEGER I, N, J, NP, KOT
C        FORMAT STATEMENTS (STATEMENTS 20 TO 31).
  20  FORMAT(1H2,14X,18HTHE AGE OF FLOW IS,F10.4,2X,4HMIN.)
  21  FORMAT(1HK,14X,41HWITH A PLUG, THE INITIAL PRESSURE DROP IS,
     1 F10.7,3X,12HLB/SQ IN/FT.)
  22  FORMAT(1HK,14X,38HWITH A PLUG, THE EXIT PRESSURE DROP IS,
     1 F10.7, 3X, 12HLB/SQ IN/FT.)
  23  FORMAT(1HK,14X,33HTHE INCREMENT NUMBER IN LENGTH IS,I4,2H .)
  24  FORMAT(1HK,14X,2HAT,F11.3,2X,19HFEET, THE PRESSURE ,
     1 11HGRADIENT IS,F10.7,13H LB/SQ IN/FT.)
  25  FORMAT(1HK,15X,6HRADIAL,36X,6HRADIAL,6X,13HAGE AT CENTRE)
  26  FORMAT(1H ,14X,9HINCREMENT,6X,6HRADIUS,6X,8HVELOCITY,4X,
     1 14HINCREMENT FLOW, 2X, 12HOF INCREMENT)
  27  FORMAT(1HS,17X,3HNO.,10X,4H(FT),7X,8H(FT/SEC),6X,
     1 11H(CU FT/SEC),7X,5H(MIN))
  28  FORMAT(1H ,28X,F8.5,4X,F8.5)
  29  FORMAT(1H ,17X,I2,35X,F10.7,5X,F13.4)
  30  FORMAT(1HK,14X,18HTHE RENOLDS NO. IS,E15.8,2H .)
  31  FORMAT(1HK,14X,19HTHE PLUG RADIUS IS ,F10.7,2X,5HFEET.)
C        PRINTING PROCESS.
      WRITE(6,20) TAGE
      DELP=TW*2./RF/144.
      IF (KOT.LT.1) GO TO 10
      DE=RF-RR
      IF (KOT.LT.2) GO TO 11
```

```
      WRITE(6,21) DELP
      WRITE(6,31) DE
      GO TO 12
   11 WRITE(6,22) DELP
      WRITE(6,31) DE
      GO TO 12
   10 WRITE(6,23) J
      WRITE(6,24) PL(J), DELP
   12 WRITE(6,25)
      WRITE(6,26)
      WRITE(6,27)
      DO 13 I=1,N
      R(I)=RF-R1(I)
      I2=3*I-1
      WRITE(6,28) R(I), V1(I)
   13 WRITE(6,29) I, Q(I), T(I2)
      NP=N+1
      R(NP)=0.00
      WRITE(6,28) R(NP), V1(NP)
C        CALCULATE AND PRINT OUT REYNOLDS NUMBER.
      REN=REC/TW
      WRITE(6,30) REN
      RETURN
      END
```

```
      SUBROUTINE WRITE2 (TAGE, PP, DP, JJ)
C   'WRITE2' IS CALLED BY 'TIME'.
C   'WRITE2' PRINTS OUT THE ACCUMULATED PRESSURE DROP.
C
C     LIST OF SYMBOLS
C        TAGE    - DURATION OF FLOW, MIN.
C        PP( )   - DISTANCE FROM PIPE ENTRANCE, FT.
C        DP( )   - TOTAL PRESSURE DROP AFTER A DISTANCE OF PP( ).
C        J       - INTEGER SPECIFYING PP( ) AND DP( ) EXTENDING
C                  TO JJ.
      REAL TAGE, PP(100), DP(100)
      INTEGER J, JJ
C        FORMAT STATEMENTS (STATEMENTS 10 TO 14).
  10  FORMAT(1H2,14X,18HTHE AGE OF FLOW IS,F10.4,2X,4HMIN.)
  11  FORMAT(1HK,29X,22HDISTANCE FROM ENTRANCE,10X,8HPRESSURE)
  12  FORMAT(1HS,35X,6H(FEET),19X,10H(LB/SQ IN))
  13  FORMAT(1H ,34X,F11.3,14X,F11.5)
  14  FORMAT(1HL,14X,4HWITH,F10.1,2X,25HFT., THE DROP IN PRESSURE,
     1 3H IS,F10.4,2X,9HLB/SQ IN.)
C        PRINTING PROCESS.
      WRITE(6,10) TAGE
      WRITE(6,11)
      WRITE(6,12)
      WRITE(6,13) (PP(J), DP(J), J=1,JJ)
      WRITE(6,14) PP(JJ), DP(JJ)
      RETURN
      END
```

APPENDIX 4

COMPUTER SAMPLE OUTPUT

```
THERE ARE 18 VALUES OF SHEAR STRESS.

FOR TOW(  1 ) =    0.0000 ,THERE ARE  2 DATA POINTS.

   TIME - SHEAR RATE   TIME - SHEAR RATE   TIME - SHEAR RATE
    0.0000     0.0000 4000.0000     0.0000

FOR TOW(  2 ) =   10.0000 ,THERE ARE 12 DATA POINTS.

   TIME - SHEAR RATE   TIME - SHEAR RATE   TIME - SHEAR RATE
    0.0000     0.0010    5.0000     0.2700   10.0000     0.3900
   20.0000     0.5700   60.0000     0.9800  100.0000     1.2200
  200.0000     1.5800  400.0000     1.9500  700.0000     3.5100
 1000.0000     4.0600 1500.0000     3.9700 4000.0000     4.0000

FOR TOW(  3 ) =   20.0000 ,THERE ARE 14 DATA POINTS.

   TIME - SHEAR RATE   TIME - SHEAR RATE   TIME - SHEAR RATE
    0.0000     0.0100    5.0000     1.8000   10.0000     2.4000
   20.0000     3.3000   40.0000     4.4000   60.0000     5.0000
  100.0000     5.8200  200.0000     7.1000  300.0000     7.9700
  400.0000     8.5600  700.0000    19.1900 1000.0000    11.2200
 1500.0000    13.4000 4000.0000    14.3000

FOR TOW(  4 ) =   30.0000 ,THERE ARE 14 DATA POINTS.

   TIME - SHEAR RATE   TIME - SHEAR RATE   TIME - SHEAR RATE
    0.0000     0.0300    5.0000     4.7500   10.0000     7.3000
   20.0000     9.2500   40.0000    11.2500   60.0000    12.5000
  100.0000    14.3500  200.0000    15.8000  300.0000    16.9000
  400.0000    17.8000  700.0000    20.4500 1000.0000    23.2000
 1500.0000    27.5000 4000.0000    29.2000

FOR TOW(  5 ) =   40.0000 ,THERE ARE 14 DATA POINTS.

   TIME - SHEAR RATE   TIME - SHEAR RATE   TIME - SHEAR RATE
    0.0000     0.1000    5.0000    10.6000   10.0000    15.5000
   20.0000    13.7000   40.0000    21.9800   60.0000    23.6000
  100.0000    25.7000  200.0000    28.5000  300.0000    30.6500
  400.0000    32.2000  700.0000    35.8000 1000.0000    39.6000
 1500.0000    45.6000 4000.0000    48.0000

FOR TOW(  6 ) =   50.0000 ,THERE ARE 14 DATA POINTS.

   TIME - SHEAR RATE   TIME - SHEAR RATE   TIME - SHEAR RATE
    0.0000     0.3500    5.0000    19.7000   10.0000    26.3000
   20.0000    31.2000   40.0000    35.5000   60.0000    38.0000
  100.0000    40.6000  200.0000    43.5000  300.0000    45.3000
  400.0000    47.1000  700.0000    52.4000 1000.0000    57.8000
 1500.0000    66.8000 4000.0000    70.0000

FOR TOW(  7 ) =   60.0000 ,THERE ARE 14 DATA POINTS.

   TIME - SHEAR RATE   TIME - SHEAR RATE   TIME - SHEAR RATE
    0.0000     0.9700    5.0000    31.5000   10.0000    40.8000
   20.0000    47.3000   40.0000    52.5000   60.0000    55.7000
  100.0000    59.2000  200.0000    63.9000  300.0000    66.2000
```

```
   400.0000    68.2000  700.0000    74.5000 1000.0000    80.7000
  1500.0000    91.1000 4000.0000    95.0000

FOR TOW(  8 ) =    70.0000 ,THERE ARE 14 DATA POINTS.

    TIME - SHEAR RATE    TIME - SHEAR RATE    TIME - SHEAR RATE
     0.0000     2.1300     5.0000    46.8000    10.0000    58.0000
    20.0000    66.3000    40.0000    73.5000    60.0000    76.7000
   100.0000    81.5000   200.0000    86.0000   300.0000    88.4000
   400.0000    90.7000   700.0000    98.0000  1000.0000   107.8000
  1500.0000   117.5000  4000.0000   122.0000

FOR TOW(  9 ) =    80.0000 ,THERE ARE 14 DATA POINTS.

    TIME - SHEAR RATE    TIME - SHEAR RATE    TIME - SHEAR RATE
     0.0000     4.1200     5.0000    64.7000    10.0000    78.0000
    20.0000    88.2000    40.0000    95.7000    60.0000   100.1000
   100.0000   105.3000   200.0000   110.0000   300.0000   112.7000
   400.0000   115.6000   700.0000   124.0000  1000.0000   132.2000
  1500.0000   145.9000  4000.0000   151.0000

FOR TOW( 10 ) =   100.0000 ,THERE ARE 15 DATA POINTS.

    TIME - SHEAR RATE    TIME - SHEAR RATE    TIME - SHEAR RATE
     0.0000    11.8000     5.0000   110.0000    10.0000   127.0000
    20.0000   140.0000    30.0000   145.0000    40.0000   147.0000
    60.0000   153.0000   100.0000   158.0000   200.0000   162.4000
   300.0000   166.0000   400.0000   169.0000   700.0000   179.5000
  1000.0000   190.5000  1500.0000   209.0000  4000.0000   215.0000

FOR TOW( 11 ) =   120.0000 ,THERE ARE 14 DATA POINTS.

    TIME - SHEAR RATE    TIME - SHEAR RATE    TIME - SHEAR RATE
     0.0000    26.2000     5.0000   163.0000    10.0000   181.0000
    20.0000   198.0000    40.0000   208.0000    60.0000   213.0000
   100.0000   220.0000   200.0000   227.0000   300.0000   230.5000
   400.0000   234.0000   700.0000   245.5000  1000.0000   256.5000
  1500.0000   275.0000  4000.0000   282.0000

FOR TOW( 12 ) =   140.0000 ,THERE ARE 15 DATA POINTS.

    TIME - SHEAR RATE    TIME - SHEAR RATE    TIME - SHEAR RATE
     0.0000    48.6000     5.0000   223.0000    10.0000   241.0000
    20.0000   261.0000    30.0000   272.0000    40.0000   280.0000
    60.0000   288.0000   100.0000   297.0000   200.0000   302.5000
   300.0000   306.5000   400.0000   310.5000   700.9000   322.0000
  1000.0000   334.0000  1500.0000   353.0000  4000.0000   360.0000

FOR TOW( 13 ) =   160.0000 ,THERE ARE 15 DATA POINTS.

    TIME - SHEAR RATE    TIME - SHEAR RATE    TIME - SHEAR RATE
     0.0000    79.0000     5.0000   289.0000    10.0000   308.0000
    20.0000   325.0000    30.0000   330.0000    40.0000   342.0000
    60.0000   348.0000   100.0000   354.0000   200.0000   358.0000
   300.0000   363.0000   400.0000   367.5000   700.0000   380.5000
  1000.0000   398.0000  1500.0000   415.5000  4000.0000   423.0000

FOR TOW( 14 ) =   180.0000 ,THERE ARE 15 DATA POINTS.
```

```
   TIME - SHEAR RATE   TIME - SHEAR RATE   TIME - SHEAR RATE
    0.0000  116.0000      5.0000  353.0000    10.0000  375.0000
   20.0000  400.0000     30.0000  408.0000    40.0000  412.0000
   60.0000  418.0000    100.0000  426.0000   200.0000  432.5000
  300.0000  436.5000    400.0000  441.0000   700.0000  453.0000
 1000.0000  465.5000   1500.0000  485.5000  4000.0000  493.0000


FOR TOW( 15 ) =  200.0000 ,THERE ARE 15 DATA POINTS.

   TIME - SHEAR RATE   TIME - SHEAR RATE   TIME - SHEAR RATE
    0.0000  158.0000      5.0000  420.0000    10.0000  443.0000
   20.0000  467.0000     30.0000  475.0000    40.0000  481.5000
   60.0000  490.0000    100.0000  498.0000   200.0000  503.0000
  300.0000  507.5000    400.0000  512.0000   700.0000  525.0000
 1000.0000  538.0000   1500.0000  560.0000  4000.0000  568.0000


FOR TOW( 16 ) =  240.0000 ,THERE ARE 15 DATA POINTS.

   TIME - SHEAR RATE   TIME - SHEAR RATE   TIME - SHEAR RATE
    0.0000  253.0000      5.0000  550.0000    10.0000  576.0000
   20.0000  601.0000     30.0000  609.0000    40.0000  615.0000
   60.0000  623.0000    100.0000  632.0000   200.0000  637.5000
  300.0000  642.0000    400.0000  647.0000   700.0000  661.0000
 1000.0000  630.0000   1500.0000  698.0000  4000.0000  705.0000


FOR TOW( 17 ) =  280.0000 ,THERE ARE 15 DATA POINTS.

   TIME - SHEAR RATE   TIME - SHEAR RATE   TIME - SHEAR RATE
    0.0000  356.0000      5.0000  679.0000    10.0000  705.0000
   20.0000  737.0000     30.0000  746.0000    40.0000  752.5000
   60.0000  762.0000    100.0000  771.0000   200.0000  776.5000
  300.0000  781.0000    400.0000  785.5000   700.0000  799.0000
 1000.0000  812.5000   1500.0000  835.0000  4000.0000  843.0000


FOR TOW( 18 ) =  320.0000 ,THERE ARE 15 DATA POINTS.

   TIME - SHEAR RATE   TIME - SHEAR RATE   TIME - SHEAR RATE
    0.0000  463.0000      5.0000  800.0000    10.0000  837.0000
   20.0000  867.0000     30.0000  786.0000    40.0000  882.0000
   60.0000  892.0000    100.0000  902.0000   200.0000  909.0000
  300.0000  913.0000    400.0000  917.5000   700.0000  931.0000
 1000.0000  944.0000   1500.0000  965.0000  4000.0000  973.0000
```

```
THE FLOW RATE IS   15000.000  BBL/DAY OR,

THE FLOW RATE IS  0.97474999   CUBIC FEET PER SEC.

THE RADIUS OF THE PIPE IS  0.50 FT.

THE PLUG RADIUS IS 0.00000 FT.

THE AVG. VELOCITY IS THEN 1.2411 FT/SEC.

THE DENSITY OF THE FLUID IS 54.200 LB/CU FT.

ITS LIMITING SHEAR STRESS IS 0.000 LB/SQ FT.

7  FLOW AGES ARE CALCULATED.
```

```
THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS    1 .

AT      0.000  FEET, THE PRESSURE GRADIENT IS 0.0010666 LB/SQ IN/FT.

 RADIAL                                    RADIAL      AGE AT CENTRE
INCREMENT      RADIUS      VELOCITY    INCREMENT FLOW  OF INCREMENT
   NO.         (FT)        (FT/SEC)      (CU FT/SEC)       (MIN)

               0.50000     0.00000
    1                                    0.0052759          10.0000
               0.48412     0.21339
    2                                    0.0154927          10.0000
               0.46771     0.41601
    3                                    0.0251661          10.0000
               0.45069     0.60745
    4                                    0.0342811          10.0000
               0.43301     0.78732
    5                                    0.0428171          10.0000
               0.41458     0.95517
    6                                    0.0507523          10.0000
               0.39528     1.11056
    7                                    0.0580688          10.0000
               0.37500     1.25324
    8                                    0.0647604          10.0000
               0.35355     1.38317
    9                                    0.0708180          10.0000
               0.33072     1.49997
   10                                    0.0762199          10.0000
               0.30619     1.60317
   11                                    0.0809417          10.0000
               0.27951     1.69225
   12                                    0.0849569          10.0000
               0.25000     1.76669
   13                                    0.0882575          10.0000
               0.21651     1.82669
   14                                    0.0908484          10.0000
               0.17678     1.87206
   15                                    0.0927242          10.0000
               0.12500     1.90210
   16                                    0.0933690          10.0000
               0.00000     1.92550

THE RENOLDS NO. IS 0.54016266E 03 .
```

```
THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS   2 .

AT      0.050  FEET, THE PRESSURE GRADIENT IS 0.0010666 LB/SQ IN/FT.

 RADIAL                                    RADIAL      AGE AT CENTRE
INCREMENT      RADIUS      VELOCITY    INCREMENT FLOW  OF INCREMENT
   NO.         (FT)        (FT/SEC)      (CU FT/SEC)       (MIN)

               0.50000     0.00000
    1                                    0.0052759           10.0076
               0.48393     0.21595
    2                                    0.0154927           10.0026
               0.46761     0.41725
    3                                    0.0251661           10.0016
               0.45063     0.60825
    4                                    0.0342811           10.0012
               0.43296     0.78791
    5                                    0.0428171           10.0010
               0.41453     0.95563
    6                                    0.0507523           10.0008
               0.39525     1.11093
    7                                    0.0580688           10.0007
               0.37497     1.25354
    8                                    0.0647604           10.0006
               0.35352     1.38342
    9                                    0.0708180           10.0006
               0.33069     1.50018
   10                                    0.0762199           10.0005
               0.30616     1.60335
   11                                    0.0809417           10.0005
               0.27948     1.69240
   12                                    0.0849569           10.0005
               0.24998     1.76681
   13                                    0.0882575           10.0005
               0.21648     1.82679
   14                                    0.0908484           10.0004
               0.17675     1.87214
   15                                    0.0927242           10.0004
               0.12497     1.90217
   16                                    0.0933690           10.0004
               0.00000     1.92556

THE RENOLDS NO. IS 0.54017352E 03 .
```

```
THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS   3 .

AT      0.100  FEET, THE PRESSURE GRADIENT IS 0.0010666 LB/SQ IN/FT.

 RADIAL                                          RADIAL        AGE AT CENTRE
INCREMENT       RADIUS       VELOCITY       INCREMENT FLOW   OF INCREMENT
   NO.           (FT)        (FT/SEC)        (CU FT/SEC)         (MIN)

                0.50000      0.00000
    1                                         0.0052759           10.0152
                0.48393      0.21598
    2                                         0.0154927           10.0052
                0.46761      0.41726
    3                                         0.0251661           10.0032
                0.45063      0.60825
    4                                         0.0342811           10.0024
                0.43297      0.78788
    5                                         0.0428171           10.0019
                0.41455      0.95559
    6                                         0.0507523           10.0016
                0.39526      1.11089
    7                                         0.0580688           10.0014
                0.37498      1.25350
    8                                         0.0647604           10.0013
                0.35354      1.38338
    9                                         0.0708180           10.0012
                0.33071      1.50015
   10                                         0.0762199           10.0011
                0.30617      1.60332
   11                                         0.0809417           10.0010
                0.27950      1.69238
   12                                         0.0849569           10.0010
                0.24999      1.76680
   13                                         0.0882575           10.0009
                0.21650      1.82678
   14                                         0.0908484           10.0009
                0.17677      1.87214
   15                                         0.0927242           10.0009
                0.12499      1.90218
   16                                         0.0933690           10.0009
                0.00000      1.92557

THE RENOLDS NO. IS 0.54019012E 03 .
```

```
THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS   4 .

AT      0.200  FEET, THE PRESSURE GRADIENT IS 0.0010665 LB/SQ IN/FT.

 RADIAL                                            RADIAL        AGE AT CENTRE
INCREMENT        RADIUS        VELOCITY      INCREMENT FLOW   OF INCREMENT
   NO.            (FT)         (FT/SEC)       (CU FT/SEC)        (MIN)

                0.50000       0.00000
    1                                          0.0052759          10.0303
                0.48394       0.21606
    2                                          0.0154927          10.0105
                0.46762       0.41733
    3                                          0.0251661          10.0065
                0.45064       0.60831
    4                                          0.0342811          10.0048
                0.43298       0.78792
    5                                          0.0428171          10.0038
                0.41456       0.95561
    6                                          0.0507523          10.0032
                0.39527       1.11090
    7                                          0.0580688          10.0028
                0.37500       1.25350
    8                                          0.0647604          10.0025
                0.35356       1.38338
    9                                          0.0708180          10.0023
                0.33073       1.50014
   10                                          0.0762199          10.0021
                0.30620       1.60332
   11                                          0.0809417          10.0020
                0.27952       1.69237
   12                                          0.0849569          10.0019
                0.25002       1.76680
   13                                          0.0882575          10.0019
                0.21653       1.82679
   14                                          0.0908484          10.0018
                0.17681       1.87216
   15                                          0.0927242          10.0018
                0.12505       1.90221
   16                                          0.0933690          10.0017
                0.00000       1.92562

THE RENOLDS NO. IS 0.54022028E 03 .
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THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS   5 .

AT      0.300  FEET, THE PRESSURE GRADIENT IS 0.0010664 LB/SQ IN/FT.

 RADIAL                                           RADIAL        AGE AT CENTRE
INCREMENT          RADIUS       VELOCITY     INCREMENT FLOW  OF INCREMENT
   NO.              (FT)        (FT/SEC)      (CU FT/SEC)        (MIN)

                  0.50000       0.00000
    1                                          0.0052759           10.0454
                  0.48395       0.21613
    2                                          0.0154927           10.0157
                  0.46763       0.41736
    3                                          0.0251661           10.0097
                  0.45065       0.60833
    4                                          0.0342811           10.0071
                  0.43299       0.78792
    5                                          0.0428171           10.0057
                  0.41457       0.95560
    6                                          0.0507523           10.0048
                  0.39529       1.11089
    7                                          0.0580688           10.0042
                  0.37501       1.25348
    8                                          0.0647604           10.0038
                  0.35357       1.38335
    9                                          0.0708180           10.0035
                  0.33074       1.50011
   10                                          0.0762199           10.0032
                  0.30621       1.60328
   11                                          0.0809417           10.0030
                  0.27954       1.69233
   12                                          0.0849569           10.0029
                  0.25004       1.76675
   13                                          0.0882575           10.0028
                  0.21655       1.82675
   14                                          0.0908484           10.0027
                  0.17684       1.87212
   15                                          0.0927242           10.0026
                  0.12509       1.90217
   16                                          0.0933690           10.0026
                  0.00000       1.92560

THE RENOLDS NO. IS 0.54025751E 03 .
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THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS   6 .

AT      0.500  FEET, THE PRESSURE GRADIENT IS 0.0010663 LB/SQ IN/FT.

 RADIAL                                          RADIAL        AGE AT CENTRE
INCREMENT          RADIUS        VELOCITY    INCREMENT FLOW   OF INCREMENT
   NO.              (FT)         (FT/SEC)     (CU FT/SEC)        (MIN)

                   0.50000       0.00000
    1                                          0.0052759          10.0756
                   0.48396       0.21627
    2                                          0.0154927          10.0261
                   0.46765       0.41742
    3                                          0.0251661          10.0162
                   0.45068       0.60836
    4                                          0.0342811          10.0119
                   0.43301       0.78794
    5                                          0.0428171          10.0095
                   0.41459       0.95561
    6                                          0.0507523          10.0080
                   0.39531       1.11086
    7                                          0.0580688          10.0070
                   0.37504       1.25343
    8                                          0.0647604          10.0063
                   0.35360       1.38329
    9                                          0.0708180          10.0058
                   0.33077       1.50004
   10                                          0.0762199          10.0054
                   0.30625       1.60320
   11                                          0.0809417          10.0050
                   0.27958       1.69226
   12                                          0.0849569          10.0048
                   0.25008       1.76668
   13                                          0.0882575          10.0046
                   0.21660       1.82667
   14                                          0.0908484          10.0045
                   0.17689       1.87205
   15                                          0.0927242          10.0044
                   0.12516       1.90211
   16                                          0.0933690          10.0043
                   0.00000       1.92557

THE RENOLDS NO. IS 0.54032970E 03 .
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THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS   7 .

AT      0.700  FEET, THE PRESSURE GRADIENT IS 0.0010662 LB/SQ IN/FT.

 RADIAL                                     RADIAL       AGE AT CENTRE
INCREMENT       RADIUS      VELOCITY   INCREMENT FLOW   OF INCREMENT
   NO.           (FT)       (FT/SEC)     (CU FT/SEC)        (MIN)

               0.50000      0.00000
    1                                    0.0052759          10.1058
               0.48397      0.21639
    2                                    0.0154927          10.0366
               0.46767      0.41748
    3                                    0.0251661          10.0226
               0.45070      0.60839
    4                                    0.0342811          10.0167
               0.43304      0.78795
    5                                    0.0428171          10.0133
               0.41462      0.95558
    6                                    0.0507523          10.0113
               0.39534      1.11083
    7                                    0.0580688          10.0098
               0.37506      1.25339
    8                                    0.0647604          10.0088
               0.35363      1.38324
    9                                    0.0708180          10.0081
               0.33080      1.49998
   10                                    0.0762199          10.0075
               0.30628      1.60314
   11                                    0.0809417          10.0071
               0.27961      1.69219
   12                                    0.0849569          10.0067
               0.25012      1.76661
   13                                    0.0882575          10.0065
               0.21664      1.82662
   14                                    0.0908484          10.0063
               0.17695      1.87200
   15                                    0.0927242          10.0062
               0.12525      1.90207
   16                                    0.0933690          10.0061
               0.00000      1.92556

THE RENOLDS NO. IS 0.54039767E 03 .
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THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS   8 .

AT      1.100  FEET, THE PRESSURE GRADIENT IS 0.0010659 LB/SQ IN/FT.

 RADIAL                                          RADIAL      AGE AT CENTRE
INCREMENT       RADIUS        VELOCITY      INCREMENT FLOW  OF INCREMENT
   NO.           (FT)         (FT/SEC)       (CU FT/SEC)        (MIN)

                0.50000       0.00000
    1                                         0.0052759            10.1660
                0.48398       0.21665
    2                                         0.0154927            10.0574
                0.46770       0.41762
    3                                         0.0251661            10.0356
                0.45073       0.60847
    4                                         0.0342811            10.0262
                0.43308       0.78798
    5                                         0.0428171            10.0210
                0.41466       0.95559
    6                                         0.0507523            10.0177
                0.39538       1.11081
    7                                         0.0580688            10.0155
                0.37511       1.25335
    8                                         0.0647604            10.0139
                0.35368       1.38317
    9                                         0.0708180            10.0127
                0.33085       1.49989
   10                                         0.0762199            10.0118
                0.30633       1.60304
   11                                         0.0809417            10.0111
                0.27967       1.69208
   12                                         0.0849569            10.0106
                0.25019       1.76649
   13                                         0.0882575            10.0102
                0.21672       1.82649
   14                                         0.0908484            10.0099
                0.17705       1.87189
   15                                         0.0927242            10.0097
                0.12539       1.90198
   16                                         0.0933690            10.0096
                0.00000       1.92552

THE RENOLDS NO. IS 0.54053135E 03 .
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THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS   9 .

AT      1.500  FEET, THE PRESSURE GRADIENT IS 0.0010657 LB/SQ IN/FT.

 RADIAL                                    RADIAL      AGE AT CENTRE
INCREMENT      RADIUS      VELOCITY    INCREMENT FLOW  OF INCREMENT
   NO.          (FT)       (FT/SEC)      (CU FT/SEC)        (MIN)

               0.50000     0.00000
    1                                    0.0052759           10.2262
               0.48400     0.21686
    2                                    0.0154927           10.0783
               0.46773     0.41774
    3                                    0.0251661           10.0485
               0.45077     0.60853
    4                                    0.0342811           10.0357
               0.43312     0.78800
    5                                    0.0428171           10.0286
               0.41470     0.95558
    6                                    0.0507523           10.0241
               0.39543     1.11077
    7                                    0.0580688           10.0211
               0.37516     1.25328
    8                                    0.0647604           10.0189
               0.35373     1.38309
    9                                    0.0708180           10.0173
               0.33091     1.49980
   10                                    0.0762199           10.0161
               0.30639     1.60293
   11                                    0.0809417           10.0151
               0.27974     1.69197
   12                                    0.0849569           10.0144
               0.25026     1.76639
   13                                    0.0882575           10.0139
               0.21680     1.82639
   14                                    0.0908484           10.0135
               0.17715     1.87180
   15                                    0.0927242           10.0132
               0.12553     1.90192
   16                                    0.0933690           10.0130
               0.00000     1.92551

THE RENOLDS NO. IS 0.54065609E 03 .
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THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  10 .

AT      2.300  FEET, THE PRESSURE GRADIENT IS 0.0010648 LB/SQ IN/FT.

 RADIAL                                         RADIAL      AGE AT CENTRE
INCREMENT       RADIUS       VELOCITY     INCREMENT FLOW  OF INCREMENT
  NO.            (FT)        (FT/SEC)      (CU FT/SEC)       (MIN)

                0.50000      0.00000
   1                                        0.0052759          10.3464
                0.48402      0.21715
   2                                        0.0154927          10.1200
                0.46776      0.41782
   3                                        0.0251661          10.0744
                0.45079      0.60844
   4                                        0.0342811          10.0547
                0.43313      0.78776
   5                                        0.0428171          10.0439
                0.41471      0.95519
   6                                        0.0507523          10.0370
                0.39542      1.11023
   7                                        0.0580688          10.0324
                0.37513      1.25262
   8                                        0.0647604          10.0290
                0.35368      1.38230
   9                                        0.0708180          10.0265
                0.33084      1.49888
  10                                        0.0762199          10.0247
                0.30630      1.60187
  11                                        0.0809417          10.0232
                0.27961      1.69076
  12                                        0.0849569          10.0221
                0.25009      1.76502
  13                                        0.0882575          10.0213
                0.21657      1.82489
  14                                        0.0908484          10.0207
                0.17681      1.87016
  15                                        0.0927242          10.0203
                0.12499      1.90013
  16                                        0.0933690          10.0200
                0.00000      1.92351

THE RENOLDS NO. IS 0.54109845E 03 .
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THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  11 .

AT      3.100  FEET, THE PRESSURE GRADIENT IS 0.0010646 LB/SQ IN/FT.

 RADIAL                                    RADIAL      AGE AT CENTRE
INCREMENT      RADIUS      VELOCITY    INCREMENT FLOW  OF INCREMENT
   NO.         (FT)        (FT/SEC)      (CU FT/SEC)       (MIN)

               0.50000     0.00000
    1                                    0.0052759           10.4662
               0.48405     0.21748
    2                                    0.0154927           10.1616
               0.46780     0.41807
    3                                    0.0251661           10.1002
               0.45085     0.60865
    4                                    0.0342811           10.0737
               0.43321     0.78795
    5                                    0.0428171           10.0591
               0.41479     0.95537
    6                                    0.0507523           10.0499
               0.39552     1.11042
    7                                    0.0580688           10.0436
               0.37524     1.25282
    8                                    0.0647604           10.0391
               0.35381     1.38252
    9                                    0.0708180           10.0358
               0.33099     1.49911
   10                                    0.0762199           10.0333
               0.30646     1.60215
   11                                    0.0809417           10.0313
               0.27980     1.69108
   12                                    0.0849569           10.0298
               0.25031     1.76541
   13                                    0.0882575           10.0287
               0.21685     1.82534
   14                                    0.0908484           10.0279
               0.17717     1.87070
   15                                    0.0927242           10.0273
               0.12553     1.90078
   16                                    0.0933690           10.0269
               0.00000     1.92437

THE RENOLDS NO. IS 0.54121687E 03 .
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THE AGE OF FLOW IS 4000.0000  MIN.


THE INCREMENT NUMBER IN LENGTH IS  12 .


AT      4.700  FEET, THE PRESSURE GRADIENT IS 0.0010634 LB/SQ IN/FT.


 RADIAL                                          RADIAL        AGE AT CENTRE
INCREMENT        RADIUS         VELOCITY    INCREMENT FLOW   OF INCREMENT
   NO.            (FT)          (FT/SEC)     (CU FT/SEC)         (MIN)

                 0.50000        0.00000
    1                                         0.0052759            10.7058
                 0.48407        0.21773
    2                                         0.0154927            10.2449
                 0.46783        0.41823
    3                                         0.0251661            10.1519
                 0.45088        0.60867
    4                                         0.0342811            10.1118
                 0.43323        0.78780
    5                                         0.0428171            10.0896
                 0.41481        0.95506
    6                                         0.0507523            10.0757
                 0.39552        1.10994
    7                                         0.0580688            10.0661
                 0.37523        1.25219
    8                                         0.0647604            10.0593
                 0.35378        1.38175
    9                                         0.0708180            10.0543
                 0.33093        1.49821
   10                                         0.0762199            10.0504
                 0.30639        1.60109
   11                                         0.0809417            10.0475
                 0.27969        1.68986
   12                                         0.0849569            10.0452
                 0.25016        1.76402
   13                                         0.0882575            10.0436
                 0.21663        1.82381
   14                                         0.0908484            10.0423
                 0.17686        1.86902
   15                                         0.0927242            10.0415
                 0.12502        1.89895
   16                                         0.0933690            10.0408
                 0.00000        1.92234


THE RENOLDS NO. IS 0.54179111E 03 .
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THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  13 .

AT      6.300  FEET, THE PRESSURE GRADIENT IS 0.0010628 LB/SQ IN/FT.

 RADIAL                                           RADIAL        AGE AT CENTRE
INCREMENT          RADIUS       VELOCITY     INCREMENT FLOW   OF INCREMENT
   NO.              (FT)        (FT/SEC)      (CU FT/SEC)         (MIN)

                  0.50000       0.00000
    1                                          0.0052759           10.9450
                  0.48407       0.21777
    2                                          0.0154927           10.3281
                  0.46784       0.41843
    3                                          0.0251661           10.2036
                  0.45089       0.60884
    4                                          0.0342811           10.1499
                  0.43325       0.78792
    5                                          0.0428171           10.1201
                  0.41483       0.95511
    6                                          0.0507523           10.1014
                  0.39554       1.10994
    7                                          0.0580688           10.0887
                  0.37526       1.25215
    8                                          0.0647604           10.0795
                  0.35381       1.38166
    9                                          0.0708180           10.0727
                  0.33096       1.49806
   10                                          0.0762199           10.0676
                  0.30641       1.60089
   11                                          0.0809417           10.0637
                  0.27971       1.68963
   12                                          0.0849569           10.0607
                  0.25018       1.76375
   13                                          0.0882575           10.0584
                  0.21665       1.82350
   14                                          0.0908484           10.0567
                  0.17687       1.86868
   15                                          0.0927242           10.0556
                  0.12502       1.89859
   16                                          0.0933690           10.0547
                  0.00000       1.92199

THE RENOLDS NO. IS 0.54211727E 03 .
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THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  14 .

AT      9.500  FEET, THE PRESSURE GRADIENT IS 0.0010620 LB/SQ IN/FT.

 RADIAL                                          RADIAL      AGE AT CENTRE
INCREMENT        RADIUS       VELOCITY      INCREMENT FLOW  OF INCREMENT
   NO.            (FT)        (FT/SEC)       (CU FT/SEC)       (MIN)

                 0.50000      0.00000
    1                                         0.0052759           11.4256
                 0.48403      0.21715
    2                                         0.0154927           10.4948
                 0.46778      0.41858
    3                                         0.0251661           10.3070
                 0.45084      0.60915
    4                                         0.0342811           10.2260
                 0.43320      0.78829
    5                                         0.0428171           10.1812
                 0.41479      0.95550
    6                                         0.0507523           10.1529
                 0.39551      1.11036
    7                                         0.0580688           10.1337
                 0.37523      1.25257
    8                                         0.0647604           10.1200
                 0.35378      1.38207
    9                                         0.0708180           10.1097
                 0.33094      1.49844
   10                                         0.0762199           10.1020
                 0.30639      1.60123
   11                                         0.0809417           10.0960
                 0.27970      1.68991
   12                                         0.0849569           10.0915
                 0.25017      1.76397
   13                                         0.0882575           10.0881
                 0.21664      1.82367
   14                                         0.0908484           10.0856
                 0.17687      1.86882
   15                                         0.0927242           10.0839
                 0.12502      1.89872
   16                                         0.0933690           10.0826
                 0.00000      1.92214

THE RENOLDS NO. IS 0.54249733E 03 .
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THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  15 .

AT     12.700  FEET, THE PRESSURE GRADIENT IS 0.0010620 LB/SQ IN/FT.

 RADIAL                                            RADIAL        AGE AT CENTRE
INCREMENT            RADIUS       VELOCITY     INCREMENT FLOW   OF INCREMENT
  NO.                 (FT)        (FT/SEC)      (CU FT/SEC)        (MIN)

                     0.50000      0.00000
   1                                             0.0052759           11.9099
                     0.48393      0.21585
   2                                             0.0154927           10.6619
                     0.46764      0.41854
   3                                             0.0251661           10.4105
                     0.45071      0.60955
   4                                             0.0342811           10.3021
                     0.43308      0.78890
   5                                             0.0428171           10.2422
                     0.41468      0.95627
   6                                             0.0507523           10.2044
                     0.39541      1.11125
   7                                             0.0580688           10.1788
                     0.37514      1.25358
   8                                             0.0647604           10.1603
                     0.35371      1.38316
   9                                             0.0708180           10.1467
                     0.33089      1.49961
  10                                             0.0762199           10.1363
                     0.30636      1.60245
  11                                             0.0809417           10.1284
                     0.27969      1.69117
  12                                             0.0849569           10.1223
                     0.25018      1.76526
  13                                             0.0882575           10.1178
                     0.21668      1.82500
  14                                             0.0908484           10.1144
                     0.17695      1.87018
  15                                             0.0927242           10.1121
                     0.12518      1.90013
  16                                             0.0933690           10.1104
                     0.00000      1.92364

THE RENOLDS NO. IS 0.54253830E 03 .
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THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  16 .

AT     19.100  FEET, THE PRESSURE GRADIENT IS 0.0010600 LB/SQ IN/FT.

 RADIAL                                          RADIAL        AGE AT CENTRE
INCREMENT          RADIUS       VELOCITY    INCREMENT FLOW   OF INCREMENT
   NO.              (FT)        (FT/SEC)     (CU FT/SEC)         (MIN)

                  0.50000      0.00000
    1                                         0.0052759           12.8826
                  0.48389      0.21542
    2                                         0.0154927           10.9959
                  0.46759      0.41892
    3                                         0.0251661           10.6168
                  0.45067      0.61005
    4                                         0.0342811           10.4540
                  0.43305      0.78940
    5                                         0.0428171           10.3640
                  0.41465      0.95672
    6                                         0.0507523           10.3073
                  0.39538      1.11162
    7                                         0.0580688           10.2688
                  0.37512      1.25386
    8                                         0.0647604           10.2411
                  0.35369      1.38334
    9                                         0.0708180           10.2205
                  0.33086      1.49966
   10                                         0.0762199           10.2049
                  0.30633      1.60237
   11                                         0.0809417           10.1930
                  0.27965      1.69093
   12                                         0.0849569           10.1839
                  0.25013      1.76486
   13                                         0.0882575           10.1771
                  0.21661      1.82445
   14                                         0.0908484           10.1721
                  0.17685      1.86952
   15                                         0.0927242           10.1686
                  0.12502      1.89940
   16                                         0.0933690           10.1660
                  0.00000      1.92288

THE RENOLDS NO. IS 0.54352005E 03 .
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THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  17 .

AT     25.500  FEET, THE PRESSURE GRADIENT IS 0.0010564 LB/SQ IN/FT.

 RADIAL                                        RADIAL       AGE AT CENTRE
INCREMENT         RADIUS       VELOCITY    INCREMENT FLOW  OF INCREMENT
   NO.             (FT)        (FT/SEC)     (CU FT/SEC)        (MIN)

                  0.50000      0.00000
    1                                        0.0052759          13.8454
                  0.48404      0.21754
    2                                        0.0154927          11.3278
                  0.46783      0.41971
    3                                        0.0251661          10.8225
                  0.45094      0.61024
    4                                        0.0342811          10.6056
                  0.43333      0.78909
    5                                        0.0428171          10.4857
                  0.41494      0.95597
    6                                        0.0507523          10.4102
                  0.39567      1.11049
    7                                        0.0580688          10.3587
                  0.37540      1.25240
    8                                        0.0647604          10.3218
                  0.35395      1.38155
    9                                        0.0708180          10.2944
                  0.33112      1.49755
   10                                        0.0762199          10.2736
                  0.30657      1.59995
   11                                        0.0809417          10.2577
                  0.27987      1.68822
   12                                        0.0849569          10.2456
                  0.25032      1.76187
   13                                        0.0882575          10.2365
                  0.21677      1.82126
   14                                        0.0908484          10.2298
                  0.17697      1.86616
   15                                        0.0927242          10.2252
                  0.12507      1.89597
   16                                        0.0933690          10.2217
                  0.00000      1.91946

THE RENOLDS NO. IS 0.54538569E 03 .
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THE AGE OF FLOW IS 4000.0000  MIN.


THE INCREMENT NUMBER IN LENGTH IS  18 .


AT     38.300  FEET, THE PRESSURE GRADIENT IS 0.0010491 LB/SQ IN/FT.


 RADIAL                                             RADIAL       AGE AT CENTRE
INCREMENT          RADIUS        VELOCITY      INCREMENT FLOW   OF INCREMENT
   NO.              (FT)         (FT/SEC)        (CU FT/SEC)        (MIN)

                  0.50000        0.00000
    1                                            0.0052759          15.7302
                  0.48438        0.22252
    2                                            0.0154927          11.9887
                  0.46838        0.42119
    3                                            0.0251661          11.2350
                  0.45153        0.61041
    4                                            0.0342811          10.9099
                  0.43394        0.78825
    5                                            0.0428171          10.7299
                  0.41555        0.95426
    6                                            0.0507523          10.6165
                  0.39627        1.10803
    7                                            0.0580688          10.5393
                  0.37598        1.24928
    8                                            0.0647604          10.4838
                  0.35452        1.37777
    9                                            0.0708180          10.4426
                  0.33165        1.49314
   10                                            0.0762199          10.4114
                  0.30707        1.59492
   11                                            0.0809417          10.3876
                  0.28032        1.68259
   12                                            0.0849569          10.3694
                  0.25072        1.75569
   13                                            0.0882575          10.3556
                  0.21710        1.81465
   14                                            0.0908484          10.3455
                  0.17720        1.85924
   15                                            0.0927242          10.3386
                  0.12516        1.88890
   16                                            0.0933690          10.3335
                  0.00000        1.91240


THE RENOLDS NO. IS 0.54920006E 03 .
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THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  19 .

AT     51.100  FEET, THE PRESSURE GRADIENT IS 0.0010440 LB/SQ IN/FT.

 RADIAL                                           RADIAL      AGE AT CENTRE
INCREMENT         RADIUS        VELOCITY     INCREMENT FLOW  OF INCREMENT
   NO.             (FT)         (FT/SEC)      (CU FT/SEC)        (MIN)

                  0.50000       0.00000
    1                                          0.0052759            17.5623
                  0.48458       0.22488
    2                                          0.0154927            12.6404
                  0.46867       0.42150
    3                                          0.0251661            11.6453
                  0.45184       0.61021
    4                                          0.0342811            11.2133
                  0.43425       0.78770
    5                                          0.0428171            10.9738
                  0.41586       0.95340
    6                                          0.0507523            10.8228
                  0.39659       1.10690
    7                                          0.0580688            10.7198
                  0.37630       1.24787
    8                                          0.0647604            10.6459
                  0.35483       1.37606
    9                                          0.0708180            10.5910
                  0.33196       1.49109
   10                                          0.0762199            10.5494
                  0.30737       1.59254
   11                                          0.0809417            10.5176
                  0.28061       1.67987
   12                                          0.0849569            10.4933
                  0.25100       1.75264
   13                                          0.0882575            10.4750
                  0.21736       1.81135
   14                                          0.0908484            10.4616
                  0.17745       1.85577
   15                                          0.0927242            10.4524
                  0.12541       1.88538
   16                                          0.0933690            10.4454
                  0.00000       1.90900

THE RENOLDS NO. IS 0.55185488E 03 .
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THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  20 .

AT     76.700  FEET, THE PRESSURE GRADIENT IS 0.0010403 LB/SQ IN/FT.

 RADIAL                                              RADIAL        AGE AT CENTRE
INCREMENT          RADIUS         VELOCITY     INCREMENT FLOW    OF INCREMENT
   NO.              (FT)          (FT/SEC)       (CU FT/SEC)         (MIN)

                   0.50000        0.00000
    1                                             0.0052759           21.2807
                   0.48446        0.22289
    2                                             0.0154927           13.9615
                   0.46842        0.41959
    3                                             0.0251661           12.4738
                   0.45152        0.60972
    4                                             0.0342811           11.8236
                   0.43391        0.78833
    5                                             0.0428171           11.4633
                   0.41552        0.95492
    6                                             0.0507523           11.2362
                   0.39626        1.10919
    7                                             0.0580688           11.0814
                   0.37599        1.25075
    8                                             0.0647604           10.9703
                   0.35454        1.37932
    9                                             0.0708180           10.8878
                   0.33170        1.49457
   10                                             0.0762199           10.8253
                   0.30714        1.59608
   11                                             0.0809417           10.7776
                   0.28041        1.68336
   12                                             0.0849569           10.7412
                   0.25083        1.75600
   13                                             0.0882575           10.7138
                   0.21723        1.81460
   14                                             0.0908484           10.6936
                   0.17735        1.85894
   15                                             0.0927242           10.6798
                   0.12536        1.88858
   16                                             0.0933690           10.6693
                   0.00000        1.91238

THE RENOLDS NO. IS 0.55380732E 03 .
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THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  21 .

AT    102.300  FEET, THE PRESSURE GRADIENT IS 0.0010347 LB/SQ IN/FT.

 RADIAL                                           RADIAL        AGE AT CENTRE
INCREMENT        RADIUS        VELOCITY      INCREMENT FLOW    OF INCREMENT
   NO.            (FT)         (FT/SEC)       (CU FT/SEC)          (MIN)

                0.50000        0.00000
    1                                         0.0052759            24.9241
                0.48461        0.22530
    2                                         0.0154927            15.2713
                0.46861        0.41726
    3                                         0.0251661            13.2996
                0.45165        0.60737
    4                                         0.0342811            12.4323
                0.43400        0.78642
    5                                         0.0428171            11.9517
                0.41559        0.95350
    6                                         0.0507523            11.6487
                0.39631        1.10823
    7                                         0.0580688            11.4422
                0.37604        1.25004
    8                                         0.0647604            11.2941
                0.35460        1.37870
    9                                         0.0708180            11.1842
                0.33175        1.49392
   10                                         0.0762199            11.1009
                0.30719        1.59530
   11                                         0.0809417            11.0374
                0.28046        1.68235
   12                                         0.0849569            10.9889
                0.25087        1.75472
   13                                         0.0882575            10.9524
                0.21726        1.81310
   14                                         0.0908484            10.9256
                0.17736        1.85729
   15                                         0.0927242            10.9072
                0.12533        1.88690
   16                                         0.0933690            10.8932
                0.00000        1.91084

THE RENOLDS NO. IS 0.55685342E 03 .
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THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  22 .

AT    153.500  FEET, THE PRESSURE GRADIENT IS 0.0010238 LB/SQ IN/FT.

 RADIAL                                              RADIAL       AGE AT CENTRE
INCREMENT          RADIUS        VELOCITY      INCREMENT FLOW  OF INCREMENT
   NO.              (FT)         (FT/SEC)        (CU FT/SEC)        (MIN)

                   0.50000       0.00000
    1                                             0.0052759           31.9063
                   0.48519       0.23365
    2                                             0.0154927           17.8786
                   0.46935       0.41260
    3                                             0.0251661           14.9684
                   0.45223       0.60153
    4                                             0.0342811           13.6575
                   0.43445       0.78132
    5                                             0.0428171           12.9323
                   0.41596       0.94957
    6                                             0.0507523           12.4758
                   0.39664       1.10545
    7                                             0.0580688           12.1651
                   0.37634       1.24797
    8                                             0.0647604           11.9426
                   0.35488       1.37700
    9                                             0.0708180           11.7776
                   0.33203       1.49233
   10                                             0.0762199           11.6528
                   0.30746       1.59358
   11                                             0.0809417           11.5576
                   0.28073       1.68029
   12                                             0.0849569           11.4852
                   0.25113       1.75226
   13                                             0.0882575           11.4305
                   0.21750       1.81035
   14                                             0.0908484           11.3904
                   0.17758       1.85435
   15                                             0.0927242           11.3627
                   0.12555       1.88398
   16                                             0.0933690           11.3417
                   0.00000       1.90830

THE RENOLDS NO. IS 0.56276017E 03 .
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THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  23 .

AT    204.700  FEET, THE PRESSURE GRADIENT IS 0.0010117 LB/SQ IN/FT.

 RADIAL                                    RADIAL      AGE AT CENTRE
INCREMENT      RADIUS      VELOCITY    INCREMENT FLOW  OF INCREMENT
   NO.         (FT)        (FT/SEC)      (CU FT/SEC)       (MIN)

               0.50000     0.00000
    1                                    0.0052759           38.5500
               0.48575     0.24262
    2                                    0.0154927           20.4529
               0.47022     0.41309
    3                                    0.0251661           16.6512
               0.45306     0.59710
    4                                    0.0342811           14.8927
               0.43519     0.77613
    5                                    0.0428171           13.9187
               0.41662     0.94480
    6                                    0.0507523           13.3062
               0.39724     1.10123
    7                                    0.0580688           12.8899
               0.37690     1.24399
    8                                    0.0647604           12.5924
               0.35542     1.37304
    9                                    0.0708180           12.3721
               0.33253     1.48819
   10                                    0.0762199           12.2056
               0.30794     1.58908
   11                                    0.0809417           12.0787
               0.28116     1.67525
   12                                    0.0849569           11.9822
               0.25152     1.74671
   13                                    0.0882575           11.9095
               0.21784     1.80443
   14                                    0.0908484           11.8560
               0.17785     1.84818
   15                                    0.0927242           11.8192
               0.12572     1.87781
   16                                    0.0933690           11.7910
               0.00000     1.90243

THE RENOLDS NO. IS 0.56946791E 03 .
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THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  24 .

AT    307.100  FEET, THE PRESSURE GRADIENT IS 0.0009903 LB/SQ IN/FT.

 RADIAL                                            RADIAL        AGE AT CENTRE
INCREMENT        RADIUS        VELOCITY      INCREMENT FLOW   OF INCREMENT
  NO.             (FT)         (FT/SEC)        (CU FT/SEC)        (MIN)

                 0.50000       0.00000
    1                                          0.0052759            51.3609
                 0.48612       0.24887
    2                                          0.0154927            25.4676
                 0.47103       0.42419
    3                                          0.0251661            19.9953
                 0.45411       0.59651
    4                                          0.0342811            17.3766
                 0.43620       0.77150
    5                                          0.0428171            15.9027
                 0.41757       0.94002
    6                                          0.0507523            14.9746
                 0.39814       1.09644
    7                                          0.0580688            14.3456
                 0.37776       1.23910
    8                                          0.0647604            13.8970
                 0.35624       1.36786
    9                                          0.0708180            13.5655
                 0.33332       1.48249
   10                                          0.0762199            13.3154
                 0.30868       1.58261
   11                                          0.0809417            13.1252
                 0.28186       1.66772
   12                                          0.0849569            12.9808
                 0.25215       1.73833
   13                                          0.0882575            12.8719
                 0.21839       1.79547
   14                                          0.0908484            12.7917
                 0.17830       1.83886
   15                                          0.0927242            12.7364
                 0.12604       1.86852
   16                                          0.0933690            12.6934
                 0.00000       1.89377

THE RENOLDS NO. IS 0.58178391E 03 .
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THE AGE OF FLOW IS 4000.0000  MIN.


THE INCREMENT NUMBER IN LENGTH IS  25 .


AT    409.500  FEET, THE PRESSURE GRADIENT IS 0.0009671 LB/SQ IN/FT.


 RADIAL                                          RADIAL        AGE AT CENTRE
INCREMENT      RADIUS        VELOCITY       INCREMENT FLOW   OF INCREMENT
   NO.          (FT)         (FT/SEC)        (CU FT/SEC)         (MIN)

              0.50000        0.00000
    1                                        0.0052759          64.0519
              0.48615        0.24944
    2                                        0.0154927          30.3895
              0.47128        0.43437
    3                                        0.0251661          23.2903
              0.45471        0.60690
    4                                        0.0342811          19.8537
              0.43703        0.77607
    5                                        0.0428171          17.8899
              0.41848        0.94145
    6                                        0.0507523          16.6473
              0.39909        1.09513
    7                                        0.0580688          15.8058
              0.37872        1.23573
    8                                        0.0647604          15.2062
              0.35717        1.36275
    9                                        0.0708180          14.7636
              0.33421        1.47570
   10                                        0.0762199          14.4302
              0.30950        1.57411
   11                                        0.0809417          14.1769
              0.28259        1.65744
   12                                        0.0849569          13.9848
              0.25275        1.72687
   13                                        0.0882575          13.8399
              0.21881        1.78313
   14                                        0.0908484          13.7330
              0.17850        1.82592
   15                                        0.0927242          13.6590
              0.12585        1.85541
   16                                        0.0933690          13.6008
              0.00000        1.88096


THE RENOLDS NO. IS 0.59572320E 03 .
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THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  26 .

AT    614.300  FEET, THE PRESSURE GRADIENT IS 0.0009305 LB/SQ IN/FT.

 RADIAL                                            RADIAL        AGE AT CENTRE
INCREMENT          RADIUS       VELOCITY      INCREMENT FLOW   OF INCREMENT
   NO.              (FT)        (FT/SEC)       (CU FT/SEC)         (MIN)

                  0.50000       0.00000
    1                                           0.0052759            89.9287
                  0.48607       0.24802
    2                                           0.0154927            40.1509
                  0.47133       0.44285
    3                                           0.0251661            29.7119
                  0.45513       0.62080
    4                                           0.0342811            24.7007
                  0.43785       0.79066
    5                                           0.0428171            21.8160
                  0.41961       0.94997
    6                                           0.0507523            19.9758
                  0.40039       1.09805
    7                                           0.0580688            18.7240
                  0.38011       1.23460
    8                                           0.0647604            17.8292
                  0.35861       1.35837
    9                                           0.0708180            17.1682
                  0.33565       1.46846
   10                                           0.0762199            16.6705
                  0.31093       1.56406
   11                                           0.0809417            16.2932
                  0.28396       1.64487
   12                                           0.0849569            16.0070
                  0.25404       1.71293
   13                                           0.0882575            15.7902
                  0.22001       1.76831
   14                                           0.0908484            15.6299
                  0.17960       1.81064
   15                                           0.0927242            15.5186
                  0.12689       1.84022
   16                                           0.0933690            15.4293
                  0.00000       1.86702

THE RENOLDS NO. IS 0.61917471E 03 .
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THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  27 .

AT    819.100  FEET, THE PRESSURE GRADIENT IS 0.0009075 LB/SQ IN/FT.

 RADIAL                                           RADIAL        AGE AT CENTRE
INCREMENT        RADIUS       VELOCITY       INCREMENT FLOW   OF INCREMENT
   NO.            (FT)        (FT/SEC)        (CU FT/SEC)        (MIN)

                0.50000       0.00000
    1                                          0.0052759          115.8422
                0.48607       0.24798
    2                                          0.0154927           49.8552
                0.47132       0.44310
    3                                          0.0251661           36.0758
                0.45517       0.62437
    4                                          0.0342811           29.5052
                0.43798       0.79404
    5                                          0.0428171           25.7169
                0.41981       0.95266
    6                                          0.0507523           23.2946
                0.40064       1.09993
    7                                          0.0580688           21.6403
                0.38039       1.23522
    8                                          0.0647604           20.4547
                0.35891       1.35777
    9                                          0.0708180           19.5781
                0.33596       1.46672
   10                                          0.0762199           18.9182
                0.31123       1.56111
   11                                          0.0809417           18.4185
                0.28423       1.64129
   12                                          0.0849569           18.0387
                0.25428       1.70929
   13                                          0.0882575           17.7499
                0.22022       1.76483
   14                                          0.0908484           17.5360
                0.17977       1.80739
   15                                          0.0927242           17.3868
                0.12703       1.83731
   16                                          0.0933690           17.2650
                0.00000       1.86515

THE RENOLDS NO. IS 0.63488993E 03 .
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THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  28 .

AT   1228.700  FEET, THE PRESSURE GRADIENT IS 0.0008781 LB/SQ IN/FT.

 RADIAL                                              RADIAL          AGE AT CENTRE
INCREMENT           RADIUS        VELOCITY      INCREMENT FLOW   OF INCREMENT
   NO.               (FT)         (FT/SEC)       (CU FT/SEC)         (MIN)

                    0.50000       0.00000
     1                                             0.0052759          167.4023
                    0.48609       0.24840
     2                                             0.0154927           69.2576
                    0.47139       0.44447
     3                                             0.0251661           48.8113
                    0.45530       0.62564
     4                                             0.0342811           39.1226
                    0.43812       0.79344
     5                                             0.0428171           33.5339
                    0.41994       0.95087
     6                                             0.0507523           29.9419
                    0.40075       1.09754
     7                                             0.0580688           27.4806
                    0.38046       1.23257
     8                                             0.0647604           25.7131
                    0.35894       1.35499
     9                                             0.0708180           24.4045
                    0.33595       1.46380
    10                                             0.0762199           23.4200
                    0.31116       1.55804
    11                                             0.0809417           22.6738
                    0.28411       1.63939
    12                                             0.0849569           22.1036
                    0.25413       1.70876
    13                                             0.0882575           21.6680
                    0.22005       1.76568
    14                                             0.0908484           21.3446
                    0.17961       1.80941
    15                                             0.0927242           21.1177
                    0.12690       1.84092
    16                                             0.0933690           20.9276
                    0.00000       1.87072

THE RENOLDS NO. IS 0.65615772E 03 .
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THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  29 .

AT   1638.300  FEET, THE PRESSURE GRADIENT IS 0.0008565 LB/SQ IN/FT.

 RADIAL                                                RADIAL        AGE AT CENTRE
INCREMENT            RADIUS          VELOCITY     INCREMENT FLOW  OF INCREMENT
   NO.                (FT)           (FT/SEC)      (CU FT/SEC)        (MIN)

                     0.50000         0.00000
    1                                                0.0052759          218.9524
                     0.48615         0.24952
    2                                                0.0154927           88.5185
                     0.47154         0.44685
    3                                                0.0251661           61.4208
                     0.45554         0.62813
    4                                                0.0342811           48.6664
                     0.43844         0.79528
    5                                                0.0428171           41.3201
                     0.42030         0.94985
    6                                                0.0507523           36.5875
                     0.40109         1.09402
    7                                                0.0580688           33.3308
                     0.38076         1.22764
    8                                                0.0647604           30.9848
                     0.35917         1.34948
    9                                                0.0708180           29.2450
                     0.33611         1.45837
   10                                                0.0762199           27.9355
                     0.31126         1.55350
   11                                                0.0809417           26.9404
                     0.28417         1.63653
   12                                                0.0849569           26.1764
                     0.25416         1.70745
   13                                                0.0882575           25.5911
                     0.22009         1.76576
   14                                                0.0908484           25.1558
                     0.17969         1.81065
   15                                                0.0927242           24.8487
                     0.12711         1.84382
   16                                                0.0933690           24.5860
                     0.00000         1.87571

THE RENOLDS NO. IS 0.67269129E 03 .
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THE AGE OF FLOW IS 4000.0000  MIN.


THE INCREMENT NUMBER IN LENGTH IS  30 .


AT   2457.500  FEET, THE PRESSURE GRADIENT IS 0.0008222 LB/SQ IN/FT.


 RADIAL                                              RADIAL        AGE AT CENTRE
INCREMENT          RADIUS        VELOCITY      INCREMENT FLOW   OF INCREMENT
   NO.              (FT)         (FT/SEC)       (CU FT/SEC)         (MIN)

                  0.50000       0.00000
    1                                            0.0052759          321.2860
                  0.48625       0.25133
    2                                            0.0154927          126.9181
                  0.47168       0.44668
    3                                            0.0251661           86.6102
                  0.45569       0.62936
    4                                            0.0342811           67.7317
                  0.43863       0.79674
    5                                            0.0428171           56.8954
                  0.42052       0.95090
    6                                            0.0507523           49.9108
                  0.40131       1.09301
    7                                            0.0580688           45.0800
                  0.38094       1.22366
    8                                            0.0647604           41.5830
                  0.35927       1.34307
    9                                            0.0708180           38.9781
                  0.33610       1.45125
   10                                            0.0762199           37.0071
                  0.31113       1.54793
   11                                            0.0809417           35.4999
                  0.28394       1.63287
   12                                            0.0849569           34.3367
                  0.25384       1.70567
   13                                            0.0882575           33.4432
                  0.21970       1.76573
   14                                            0.0908484           32.7778
                  0.17922       1.81206
   15                                            0.0927242           32.3036
                  0.12652       1.84783
   16                                            0.0933690           31.8837
                  0.00000       1.88272


THE RENOLDS NO. IS 0.70075740E 03 .
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THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  31 .

AT   3276.700  FEET, THE PRESSURE GRADIENT IS 0.0007982 LB/SQ IN/FT.

 RADIAL                                          RADIAL        AGE AT CENTRE
INCREMENT          RADIUS       VELOCITY    INCREMENT FLOW   OF INCREMENT
   NO.              (FT)        (FT/SEC)     (CU FT/SEC)         (MIN)

                  0.50000       0.00000
    1                                         0.0052759          423.1238
                  0.48626       0.25138
    2                                         0.0154927          165.4138
                  0.47161       0.44332
    3                                         0.0251661          111.8873
                  0.45552       0.62733
    4                                         0.0342811           86.8118
                  0.43841       0.79627
    5                                         0.0428171           72.4699
                  0.42028       0.95136
    6                                         0.0507523           63.2322
                  0.40107       1.09388
    7                                         0.0580688           56.8365
                  0.38070       1.22473
    8                                         0.0647604           52.1961
                  0.35903       1.34445
    9                                         0.0708180           48.7270
                  0.33586       1.45317
   10                                         0.0762199           46.0893
                  0.31090       1.55063
   11                                         0.0809417           44.0620
                  0.28373       1.63652
   12                                         0.0849569           42.4922
                  0.25369       1.71040
   13                                         0.0882575           41.2842
                  0.21962       1.77159
   14                                         0.0908484           40.3838
                  0.17928       1.81896
   15                                         0.0927242           39.7361
                  0.12686       1.85682
   16                                         0.0933690           39.1471
                  0.00000       1.89456

THE RENOLDS NO. IS 0.72184969E 03 .
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THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  32 .

AT   4915.100  FEET, THE PRESSURE GRADIENT IS 0.0007633 LB/SQ IN/FT.

 RADIAL                                    RADIAL      AGE AT CENTRE
INCREMENT      RADIUS      VELOCITY     INCREMENT FLOW  OF INCREMENT
   NO.          (FT)       (FT/SEC)       (CU FT/SEC)        (MIN)

               0.50000     0.00000
    1                                    0.0052759           624.3120
               0.48649     0.25554
    2                                    0.0154927           242.6097
               0.47191     0.44076
    3                                    0.0251661           162.9296
               0.45570     0.62162
    4                                    0.0342811           125.2305
               0.43846     0.79129
    5                                    0.0428171           103.7339
               0.42024     0.94781
    6                                    0.0507523            89.9208
               0.40097     1.09153
    7                                    0.0580688            80.3567
               0.38055     1.22314
    8                                    0.0647604            73.4080
               0.35884     1.34311
    9                                    0.0708180            68.2006
               0.33563     1.45186
   10                                    0.0762199            64.2266
               0.31064     1.54945
   11                                    0.0809417            61.1587
               0.28342     1.63563
   12                                    0.0849569            58.7737
               0.25332     1.71005
   13                                    0.0882575            56.9329
               0.21919     1.77199
   14                                    0.0908484            55.5586
               0.17876     1.82023
   15                                    0.0927242            54.5522
               0.12622     1.86181
   16                                    0.0933690            53.5989
               0.00000     1.90290

THE RENOLDS NO. IS 0.75479017E 03 .
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THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  33 .

AT   6553.500  FEET, THE PRESSURE GRADIENT IS 0.0007391 LB/SQ IN/FT.

 RADIAL                                          RADIAL       AGE AT CENTRE
INCREMENT          RADIUS        VELOCITY   INCREMENT FLOW  OF INCREMENT
   NO.              (FT)         (FT/SEC)      (CU FT/SEC)        (MIN)

                   0.50000       0.00000
    1                                          0.0052759          820.6145
                   0.48667       0.25888
    2                                          0.0154927          319.0955
                   0.47220       0.44181
    3                                          0.0251661          214.0996
                   0.45598       0.61909
    4                                          0.0342811          163.8440
                   0.43865       0.78702
    5                                          0.0428171          135.1276
                   0.42034       0.94367
    6                                          0.0507523          116.6906
                   0.40100       1.08802
    7                                          0.0580688          103.9394
                   0.38052       1.22008
    8                                          0.0647604           94.6773
                   0.35875       1.34048
    9                                          0.0708180           87.7267
                   0.33549       1.44988
   10                                          0.0762199           82.4064
                   0.31045       1.54820
   11                                          0.0809417           78.2852
                   0.28320       1.63521
   12                                          0.0849569           75.0737
                   0.25307       1.71047
   13                                          0.0882575           72.5897
                   0.21892       1.77329
   14                                          0.0908484           70.7315
                   0.17847       1.82292
   15                                          0.0927242           69.3474
                   0.12593       1.86756
   16                                          0.0933690           67.9974
                   0.00000       1.91149

THE RENOLDS NO. IS 0.77948399E 03 .
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THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  34 .

AT   9830.300  FEET, THE PRESSURE GRADIENT IS 0.0007008 LB/SQ IN/FT.

 RADIAL                                          RADIAL        AGE AT CENTRE
INCREMENT      RADIUS        VELOCITY       INCREMENT FLOW   OF INCREMENT
  NO.           (FT)         (FT/SEC)        (CU FT/SEC)        (MIN)

              0.50000        0.00000
   1                                          0.0052759         1219.9622
              0.48650        0.25546
   2                                          0.0154927          470.6873
              0.47220        0.45635
   3                                          0.0251661          314.9324
              0.45633        0.62663
   4                                          0.0342811          240.7235
              0.43914        0.78900
   5                                          0.0428171          197.9232
              0.42084        0.94135
   6                                          0.0507523          170.3327
              0.40145        1.08372
   7                                          0.0580688          151.2167
              0.38091        1.21522
   8                                          0.0647604          137.3156
              0.35909        1.33570
   9                                          0.0708180          126.8602
              0.33578        1.44517
  10                                          0.0762199          118.8298
              0.31068        1.54359
  11                                          0.0809417          112.5871
              0.28337        1.63077
  12                                          0.0849569          107.7088
              0.25318        1.70637
  13                                          0.0882575          103.9263
              0.21897        1.76980
  14                                          0.0908484          101.0805
              0.17848        1.82127
  15                                          0.0927242           98.8985
              0.12597        1.87030
  16                                          0.0933690           96.6892
              0.00000        1.91861

THE RENOLDS NO. IS 0.82213445E 03 .
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THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  35 .

AT  13107.100  FEET, THE PRESSURE GRADIENT IS 0.0006633 LB/SQ IN/FT.

 RADIAL                                              RADIAL        AGE AT CENTRE
INCREMENT          RADIUS        VELOCITY      INCREMENT FLOW    OF INCREMENT
   NO.              (FT)         (FT/SEC)        (CU FT/SEC)         (MIN)

                   0.50000       0.00000
    1                                             0.0052759         1639.6906
                   0.48600       0.24703
    2                                             0.0154927          619.6331
                   0.47200       0.48300
    3                                             0.0251661          412.5905
                   0.45686       0.64694
    4                                             0.0342811          316.7688
                   0.44007       0.80018
    5                                             0.0428171          260.6045
                   0.42198       0.94663
    6                                             0.0507523          224.0945
                   0.40270       1.08398
    7                                             0.0580688          198.6876
                   0.38218       1.21139
    8                                             0.0647604          180.1618
                   0.36033       1.32885
    9                                             0.0708180          166.1980
                   0.33695       1.43610
   10                                             0.0762199          155.4500
                   0.31176       1.53287
   11                                             0.0809417          147.0757
                   0.28435       1.61885
   12                                             0.0849569          140.5186
                   0.25403       1.69361
   13                                             0.0882575          135.4251
                   0.21966       1.75650
   14                                             0.0908484          131.5664
                   0.17899       1.80995
   15                                             0.0927242          128.5321
                   0.12632       1.86192
   16                                             0.0933690          125.3857
                   0.00000       1.91308

THE RENOLDS NO. IS 0.86855289E 03 .
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THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  36 .

AT  19660.700  FEET, THE PRESSURE GRADIENT IS 0.0006058 LB/SQ IN/FT.

 RADIAL                                           RADIAL       AGE AT CENTRE
INCREMENT          RADIUS       VELOCITY     INCREMENT FLOW   OF INCREMENT
  NO.               (FT)        (FT/SEC)      (CU FT/SEC)         (MIN)

                   0.50000      0.00000
   1                                           0.0052759          2541.7301
                   0.48515      0.23190
   2                                           0.0154927           924.8430
                   0.47008      0.45464
   3                                           0.0251661           601.5372
                   0.45507      0.69450
   4                                           0.0342811           461.3803
                   0.43940      0.85065
   5                                           0.0428171           382.1692
                   0.42218      0.98003
   6                                           0.0507523           329.9772
                   0.40344      1.10383
   7                                           0.0580688           293.0526
                   0.38326      1.22132
   8                                           0.0647604           265.8385
                   0.36161      1.33082
   9                                           0.0708180           245.1672
                   0.33832      1.43158
  10                                           0.0762199           229.1561
                   0.31314      1.52304
  11                                           0.0809417           216.6160
                   0.28566      1.60464
  12                                           0.0849569           206.7589
                   0.25521      1.67570
  13                                           0.0882575           199.0834
                   0.22063      1.73572
  14                                           0.0908484           193.1553
                   0.17970      1.79161
  15                                           0.0927242           188.2916
                   0.12678      1.84650
  16                                           0.0933690           183.1433
                   0.00000      1.90050

THE RENOLDS NO. IS 0.95098627E 03 .
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THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  37 .

AT  26214.300  FEET, THE PRESSURE GRADIENT IS 0.0005705 LB/SQ IN/FT.

 RADIAL                                                RADIAL        AGE AT CENTRE
INCREMENT           RADIUS        VELOCITY        INCREMENT FLOW   OF INCREMENT
   NO.               (FT)         (FT/SEC)         (CU FT/SEC)         (MIN)

                    0.50000       0.00000
     1                                               0.0052759         3471.2680
                    0.48443       0.22262
     2                                               0.0154927         1258.3826
                    0.46785       0.40392
     3                                               0.0251661          798.7952
                    0.45137       0.65939
     4                                               0.0342811          601.8069
                    0.43543       0.87785
     5                                               0.0428171          498.2634
                    0.41880       1.03195
     6                                               0.0507523          431.9800
                    0.40082       1.15359
     7                                               0.0580688          385.0449
                    0.38126       1.26043
     8                                               0.0647604          350.1418
                    0.36007       1.36099
     9                                               0.0708180          323.3640
                    0.33713       1.45473
    10                                               0.0762199          302.4691
                    0.31220       1.54067
    11                                               0.0809417          286.0118
                    0.28490       1.61765
    12                                               0.0849569          273.0292
                    0.25456       1.68468
    13                                               0.0882575          262.8809
                    0.22004       1.74317
    14                                               0.0908484          254.8781
                    0.17917       1.80023
    15                                               0.0927242          248.0978
                    0.12635       1.85623
    16                                               0.0933690          240.8594
                    0.00000       1.91123

THE RENOLDS NO. IS 0.10098925E 04 .
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THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  38 .

AT  39321.500  FEET, THE PRESSURE GRADIENT IS 0.0005263 LB/SQ IN/FT.

 RADIAL                                                RADIAL          AGE AT CENTRE
INCREMENT          RADIUS          VELOCITY       INCREMENT FLOW     OF INCREMENT
   NO.              (FT)           (FT/SEC)        (CU FT/SEC)          (MIN)

                  0.50000          0.00000
    1                                               0.0052759          4000.0000
                  0.48334          0.20843
    2                                               0.0154927          1959.8917
                  0.46638          0.39942
    3                                               0.0251661          1240.6861
                  0.44810          0.55611
    4                                               0.0342811           913.9309
                  0.42898          0.75418
    5                                               0.0428171           736.9441
                  0.41027          0.98923
    6                                               0.0507523           631.1133
                  0.39173          1.18149
    7                                               0.0580688           561.2689
                  0.37249          1.32967
    8                                               0.0647604           511.0515
                  0.35202          1.44814
    9                                               0.0708180           472.9512
                  0.32995          1.54560
   10                                               0.0762199           443.3637
                  0.30591          1.62743
   11                                               0.0809417           420.0828
                  0.27943          1.69679
   12                                               0.0849569           401.7065
                  0.24984          1.75619
   13                                               0.0882575           387.1198
                  0.21605          1.81365
   14                                               0.0908484           375.1672
                  0.17599          1.87033
   15                                               0.0927242           364.7237
                  0.12418          1.92595
   16                                               0.0933690           353.5039
                  0.00000          1.98063

THE RENOLDS NO. IS 0.10947392E 04 .
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THE AGE OF FLOW IS 4000.0000  MIN.


THE INCREMENT NUMBER IN LENGTH IS  39 .


AT  52428.699  FEET, THE PRESSURE GRADIENT IS 0.0005133 LB/SQ IN/FT.


 RADIAL                                           RADIAL         AGE AT CENTRE
INCREMENT        RADIUS        VELOCITY      INCREMENT FLOW    OF INCREMENT
   NO.            (FT)        (FT/SEC)         (CU FT/SEC)         (MIN)

                0.50000       0.00000
    1                                          0.0052759          4000.0000
                0.48299       0.20439
    2                                          0.0154927          2676.1592
                0.46567       0.39393
    3                                          0.0251661          1692.1559
                0.44761       0.57317
    4                                          0.0342811          1249.8555
                0.42837       0.71752
    5                                          0.0428171           998.8805
                0.40786       0.87587
    6                                          0.0507523           842.7629
                0.38695       1.07550
    7                                          0.0580688           740.7063
                0.36604       1.27395
    8                                          0.0647604           669.7897
                0.34470       1.44384
    9                                          0.0708180           617.9813
                0.32237       1.57847
   10                                          0.0762199           578.9446
                0.29844       1.68531
   11                                          0.0809417           548.8495
                0.27232       1.76927
   12                                          0.0849569           525.3493
                0.24327       1.84034
   13                                          0.0882575           506.4663
                0.21022       1.90862
   14                                          0.0908484           490.5778
                0.17116       1.97416
   15                                          0.0927242           476.5180
                0.12074       2.03696
   16                                          0.0933690           461.4151
                0.00000       2.09745


THE RENOLDS NO. IS 0.11224981E 04 .
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THE AGE OF FLOW IS 4000.0000  MIN.


THE INCREMENT NUMBER IN LENGTH IS  40 .


AT  78643.099  FEET, THE PRESSURE GRADIENT IS 0.0005180 LB/SQ IN/FT.


 RADIAL                                          RADIAL        AGE AT CENTRE
INCREMENT         RADIUS       VELOCITY     INCREMENT FLOW   OF INCREMENT
   NO.             (FT)        (FT/SEC)       (CU FT/SEC)        (MIN)

                 0.50000       0.00000
    1                                          0.0052759          4000.0000
                 0.48313       0.20611
    2                                          0.0154927          4000.0000
                 0.46606       0.40103
    3                                          0.0251661          2557.2172
                 0.44832       0.58495
    4                                          0.0342811          1882.7854
                 0.42986       0.76007
    5                                          0.0428171          1528.0941
                 0.41064       0.92405
    6                                          0.0507523          1296.3970
                 0.39034       1.06038
    7                                          0.0580688          1129.8494
                 0.36872       1.19188
    8                                          0.0647604          1008.8677
                 0.34582       1.32973
    9                                          0.0708180           920.1718
                 0.32175       1.47728
   10                                          0.0762199           854.2496
                 0.29641       1.61829
   11                                          0.0809417           804.8380
                 0.26930       1.73915
   12                                          0.0849569           767.2384
                 0.23965       1.84344
   13                                          0.0882575           736.9263
                 0.20640       1.94370
   14                                          0.0908484           711.0485
                 0.16758       2.03974
   15                                          0.0927242           688.1705
                 0.11804       2.13093
   16                                          0.0933690           663.9801
                 0.00000       2.21803


THE RENOLDS NO. IS 0.11122801E 04 .
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THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  41 .

AT 104857.498  FEET, THE PRESSURE GRADIENT IS 0.0005109 LB/SQ IN/FT.

 RADIAL                                             RADIAL         AGE AT CENTRE
INCREMENT         RADIUS         VELOCITY       INCREMENT FLOW   OF INCREMENT
   NO.             (FT)          (FT/SEC)        (CU FT/SEC)          (MIN)

                  0.50000        0.00000
    1                                            0.0052759           4000.0000
                  0.48292        0.20343
    2                                            0.0154927           4000.0000
                  0.46562        0.39655
    3                                            0.0251661           3448.3989
                  0.44770        0.58111
    4                                            0.0342811           2535.7289
                  0.42910        0.75547
    5                                            0.0428171           2048.7968
                  0.40972        0.92136
    6                                            0.0507523           1735.3852
                  0.38952        1.07911
    7                                            0.0580688           1513.3710
                  0.36838        1.22688
    8                                            0.0647604           1350.9555
                  0.34606        1.35604
    9                                            0.0708180           1229.5218
                  0.32226        1.47804
   10                                            0.0762199           1136.8609
                  0.29678        1.59831
   11                                            0.0809417           1066.3125
                  0.26932        1.71626
   12                                            0.0849569           1012.0950
                  0.23934        1.83046
   13                                            0.0882575            967.9571
                  0.20588        1.94104
   14                                            0.0908484            930.0402
                  0.16700        2.04766
   15                                            0.0927242            896.6232
                  0.11759        2.15002
   16                                            0.0933690            861.6444
                  0.00000        2.24956

THE RENOLDS NO. IS 0.11278065E 04 .
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THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  42 .

AT 157286.297  FEET, THE PRESSURE GRADIENT IS 0.0005044 LB/SQ IN/FT.

 RADIAL                                            RADIAL       AGE AT CENTRE
INCREMENT          RADIUS       VELOCITY      INCREMENT FLOW   OF INCREMENT
   NO.              (FT)        (FT/SEC)        (CU FT/SEC)        (MIN)

                  0.50000       0.00000
    1                                           0.0052759        4000.0000
                  0.48271       0.20109
    2                                           0.0154927        4000.0000
                  0.46519       0.39191
    3                                           0.0251661        4000.0000
                  0.44707       0.57599
    4                                           0.0342811        3863.2791
                  0.42832       0.75197
    5                                           0.0428171        3111.4059
                  0.40883       0.91811
    6                                           0.0507523        2614.3184
                  0.38851       1.07523
    7                                           0.0580688        2260.6503
                  0.36724       1.22368
    8                                           0.0647604        2011.3304
                  0.34487       1.36358
    9                                           0.0708180        1832.0208
                  0.32120       1.49484
   10                                           0.0762199        1696.0218
                  0.29594       1.61719
   11                                           0.0809417        1589.3989
                  0.26868       1.73054
   12                                           0.0849569        1503.7045
                  0.23883       1.83994
   13                                           0.0882575        1431.8721
                  0.20544       1.94868
   14                                           0.0908484        1369.6580
                  0.16662       2.05589
   15                                           0.0927242        1314.6904
                  0.11729       2.16066
   16                                           0.0933690        1257.2867
                  0.00000       2.26408

THE RENOLDS NO. IS 0.11423302E 04 .
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THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  43 .

AT 209715.096  FEET, THE PRESSURE GRADIENT IS 0.0005030 LB/SQ IN/FT.

 RADIAL                                            RADIAL          AGE AT CENTRE
INCREMENT          RADIUS         VELOCITY     INCREMENT FLOW   OF INCREMENT
   NO.              (FT)          (FT/SEC)      (CU FT/SEC)          (MIN)

                  0.50000         0.00000
    1                                             0.0052759          4000.0000
                  0.48266         0.20065
    2                                             0.0154927          4000.0000
                  0.46510         0.39092
    3                                             0.0251661          4000.0000
                  0.44692         0.57453
    4                                             0.0342811          4000.0000
                  0.42812         0.75063
    5                                             0.0428171          4000.0000
                  0.40862         0.91873
    6                                             0.0507523          3489.4022
                  0.38832         1.07736
    7                                             0.0580688          3019.0980
                  0.36709         1.22662
    8                                             0.0647604          2685.1503
                  0.34477         1.36686
    9                                             0.0708180          2441.9157
                  0.32115         1.49812
   10                                             0.0762199          2256.2606
                  0.29594         1.62020
   11                                             0.0809417          2110.3463
                  0.26874         1.73313
   12                                             0.0849569          1992.3374
                  0.23894         1.84203
   13                                             0.0882575          1892.5106
                  0.20559         1.94871
   14                                             0.0908484          1805.6115
                  0.16678         2.05271
   15                                             0.0927242          1728.7680
                  0.11739         2.15366
   16                                             0.0933690          1648.5850
                  0.00000         2.25277

THE RENOLDS NO. IS 0.11455215E 04 .
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THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  44 .

AT 314572.695  FEET, THE PRESSURE GRADIENT IS 0.0005017 LB/SQ IN/FT.

 RADIAL                                          RADIAL         AGE AT CENTRE
INCREMENT        RADIUS        VELOCITY     INCREMENT FLOW   OF INCREMENT
   NO.            (FT)         (FT/SEC)      (CU FT/SEC)         (MIN)

                0.50000        0.00000
    1                                         0.0052759          4000.0000
                0.48262        0.20019
    2                                         0.0154927          4000.0000
                0.46502        0.39002
    3                                         0.0251661          4000.0000
                0.44679        0.57318
    4                                         0.0342811          4000.0000
                0.42794        0.74885
    5                                         0.0428171          4000.0000
                0.40838        0.91662
    6                                         0.0507523          4000.0000
                0.38803        1.07617
    7                                         0.0580688          4000.0000
                0.36678        1.22715
    8                                         0.0647604          4000.0000
                0.34447        1.36914
    9                                         0.0708180          3660.3824
                0.32087        1.50141
   10                                         0.0762199          3376.8965
                0.29570        1.62378
   11                                         0.0809417          3152.5254
                0.26853        1.73649
   12                                         0.0849569          2969.4816
                0.23877        1.84524
   13                                         0.0882575          2813.7878
                0.20546        1.95177
   14                                         0.0908484          2678.3828
                0.16668        2.05562
   15                                         0.0927242          2558.9148
                0.11733        2.15643
   16                                         0.0933690          2434.6508
                0.00000        2.25544

THE RENOLDS NO. IS 0.11483747E 04 .
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THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  45 .

AT 419430.293  FEET, THE PRESSURE GRADIENT IS 0.0005017 LB/SQ IN/FT.

 RADIAL                                       RADIAL        AGE AT CENTRE
INCREMENT     RADIUS       VELOCITY      INCREMENT FLOW   OF INCREMENT
   NO.         (FT)       (FT/SEC)        (CU FT/SEC)        (MIN)

              0.50000      0.00000
    1                                      0.0052759          4000.0000
              0.48262      0.20018
    2                                      0.0154927          4000.0000
              0.46501      0.38999
    3                                      0.0251661          4000.0000
              0.44679      0.57311
    4                                      0.0342811          4000.0000
              0.42793      0.74875
    5                                      0.0428171          4000.0000
              0.40837      0.91651
    6                                      0.0507523          4000.0000
              0.38802      1.07604
    7                                      0.0580688          4000.0000
              0.36677      1.22699
    8                                      0.0647604          4000.0000
              0.34445      1.36901
    9                                      0.0708180          4000.0000
              0.32086      1.50172
   10                                      0.0762199          4000.0000
              0.29570      1.62464
   11                                      0.0809417          4000.0000
              0.26855      1.73766
   12                                      0.0849569          3943.9456
              0.23881      1.84663
   13                                      0.0882575          3732.8954
              0.20554      1.95334
   14                                      0.0908484          3548.9418
              0.16682      2.05737
   15                                      0.0927242          3386.5417
              0.11758      2.15833
   16                                      0.0933690          3217.6281
              0.00000      2.25798

THE RENOLDS NO. IS 0.11485142E 04 .
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```
THE AGE OF FLOW IS 4000.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  46 .

AT 528000.000  FEET, THE PRESSURE GRADIENT IS 0.0005016 LB/SQ IN/FT.

 RADIAL                                        RADIAL       AGE AT CENTRE
INCREMENT     RADIUS      VELOCITY    INCREMENT FLOW  OF INCREMENT
   NO.         (FT)       (FT/SEC)      (CU FT/SEC)        (MIN)

              0.50000     0.00000
    1                                   0.0052759        4000.0000
              0.48262     0.20014
    2                                   0.0154927        4000.0000
              0.46501     0.38993
    3                                   0.0251661        4000.0000
              0.44678     0.57304
    4                                   0.0342811        4000.0000
              0.42792     0.74865
    5                                   0.0428171        4000.0000
              0.40835     0.91639
    6                                   0.0507523        4000.0000
              0.38800     1.07589
    7                                   0.0580688        4000.0000
              0.36674     1.22682
    8                                   0.0647604        4000.0000
              0.34442     1.36883
    9                                   0.0708180        4000.0000
              0.32082     1.50151
   10                                   0.0762199        4000.0000
              0.29566     1.62441
   11                                   0.0809417        4000.0000
              0.26850     1.73741
   12                                   0.0849569        4000.0000
              0.23875     1.84639
   13                                   0.0882575        4000.0000
              0.20546     1.95319
   14                                   0.0908484        4000.0000
              0.16672     2.05733
   15                                   0.0927242        4000.0000
              0.11745     2.15846
   16                                   0.0933690        4000.0000
              0.00000     2.25809

THE RENOLDS NO. IS 0.11486808E 04 .
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```
THE AGE OF FLOW IS 4000.0000  MIN.

               DISTANCE FROM ENTRANCE           PRESSURE
                      (FEET)                   (LB/SQ IN)

                           0.000                0.00000
                           0.100                0.00011
                           0.300                0.00032
                           0.700                0.00075
                           1.500                0.00160
                           3.100                0.00330
                           6.300                0.00671
                          12.700                0.01350
                          25.500                0.02707
                          51.100                0.05393
                         102.300                0.10718
                         204.700                0.21200
                         409.500                0.41476
                         819.100                0.79683
                        1638.300                1.51721
                        3276.700                2.86709
                        6553.500                5.37418
                       13107.100                9.96792
                       26214.300               17.95730
                       52428.699               31.89005
                      104857.498               58.94426
                      209715.096              111.91983
                      419430.293              217.17788
                      528000.000              271.63797

WITH  528000.0  FT., THE DROP IN PRESSURE IS  271.6380  LB/SQ IN.
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THE AGE OF FLOW IS    0.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS    1 .

AT      0.000  FEET, THE PRESSURE GRADIENT IS 0.0030832 LB/SQ IN/FT.

 RADIAL                                         RADIAL       AGE AT CENTRE
INCREMENT        RADIUS       VELOCITY     INCREMENT FLOW   OF INCREMENT
   NO.            (FT)        (FT/SEC)      (CU FT/SEC)        (MIN)

                 0.50000      0.00000
    1                                        0.0069455              0.0000
                 0.48412      0.27854
    2                                        0.0198941              0.0000
                 0.46771      0.52706
    3                                        0.0313724              0.0000
                 0.45069      0.74636
    4                                        0.0414445              0.0000
                 0.43301      0.93765
    5                                        0.0501753              0.0000
                 0.41458      1.10231
    6                                        0.0576316              0.0000
                 0.39528      1.24167
    7                                        0.0638808              0.0000
                 0.37500      1.35718
    8                                        0.0690004              0.0000
                 0.35355      1.45055
    9                                        0.0730802              0.0000
                 0.33072      1.52374
   10                                        0.0762217              0.0000
                 0.30619      1.57889
   11                                        0.0785324              0.0000
                 0.27951      1.61825
   12                                        0.0801248              0.0000
                 0.25000      1.64412
   13                                        0.0811105              0.0000
                 0.21651      1.65878
   14                                        0.0816232              0.0000
                 0.17678      1.66548
   15                                        0.0818392              0.0000
                 0.12500      1.66791
   16                                        0.0818733              0.0000
                 0.00000      1.66865

THE RENOLDS NO. IS 0.18687134E 03 .
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THE AGE OF FLOW IS    0.0000  MIN.


              DISTANCE FROM ENTRANCE          PRESSURE
                     (FEET)                  (LB/SQ IN)

                      0.000                   0.00000
                      0.100                   0.00031
                      0.300                   0.00092
                      0.700                   0.00216
                      1.500                   0.00462
                      3.100                   0.00956
                      6.300                   0.01942
                     12.700                   0.03916
                     25.500                   0.07862
                     51.100                   0.15755
                    102.300                   0.31541
                    204.700                   0.63112
                    409.500                   1.26255
                    819.100                   2.52541
                   1638.300                   5.05113
                   3276.700                  10.10256
                   6553.500                  20.20543
                  13107.100                  40.41117
                  26214.300                  80.82266
                  52428.699                 161.64562
                 104857.498                 323.29155
                 209715.096                 646.58341
                 419430.293                1293.16713
                 528000.000                1627.90399


WITH  528000.0  FT., THE DROP IN PRESSURE IS 1627.9040  LB/SQ IN.
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THE AGE OF FLOW IS    1.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  10 .

AT      2.300  FEET, THE PRESSURE GRADIENT IS 0.0010849 LB/SQ IN/FT.

 RADIAL                                         RADIAL       AGE AT CENTRE
INCREMENT       RADIUS       VELOCITY      INCREMENT FLOW  OF INCREMENT
   NO.           (FT)       (FT/SEC)       (CU FT/SEC)        (MIN)

                0.50000      0.00000
   1                                        0.0052759          10.3586
                0.48186      0.19203
   2                                        0.0154927          10.1214
                0.46456      0.41271
   3                                        0.0251661          10.0745
                0.44744      0.61096
   4                                        0.0342811          10.0547
                0.42978      0.79559
   5                                        0.0428171          10.0438
                0.41143      0.96731
   6                                        0.0507523          10.0369
                0.39225      1.12604
   7                                        0.0580688          10.0323
                0.37210      1.27160
   8                                        0.0647604          10.0290
                0.35080      1.40405
   9                                        0.0708180          10.0265
                0.32814      1.52310
  10                                        0.0762199          10.0246
                0.30379      1.62825
  11                                        0.0809417          10.0232
                0.27733      1.71903
  12                                        0.0849569          10.0221
                0.24805      1.79486
  13                                        0.0882575          10.0212
                0.21483      1.85592
  14                                        0.0908484          10.0206
                0.17543      1.90208
  15                                        0.0927242          10.0202
                0.12410      1.93263
  16                                        0.0933690          10.0199
                0.00000      1.95612

THE RENOLDS NO. IS 0.53104627E 03 .
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THE AGE OF FLOW IS    1.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  11 .

AT      3.100  FEET, THE PRESSURE GRADIENT IS 0.0010847 LB/SQ IN/FT.

 RADIAL                                          RADIAL         AGE AT CENTRE
INCREMENT       RADIUS        VELOCITY      INCREMENT FLOW   OF INCREMENT
   NO.           (FT)         (FT/SEC)       (CU FT/SEC)         (MIN)

               0.50000       0.00000
    1                                       0.0052759            10.5050
               0.48188       0.19232
    2                                       0.0154927            10.1656
               0.46459       0.41315
    3                                       0.0251661            10.1004
               0.44748       0.61142
    4                                       0.0342811            10.0736
               0.42983       0.79605
    5                                       0.0428171            10.0589
               0.41148       0.96776
    6                                       0.0507523            10.0496
               0.39231       1.12650
    7                                       0.0580688            10.0434
               0.37217       1.27206
    8                                       0.0647604            10.0389
               0.35089       1.40452
    9                                       0.0708180            10.0356
               0.32824       1.52357
   10                                       0.0762199            10.0330
               0.30391       1.62876
   11                                       0.0809417            10.0311
               0.27747       1.71956
   12                                       0.0849569            10.0296
               0.24822       1.79544
   13                                       0.0882575            10.0285
               0.21504       1.85655
   14                                       0.0908484            10.0277
               0.17570       1.90278
   15                                       0.0927242            10.0272
               0.12451       1.93342
   16                                       0.0933690            10.0268
               0.00000       1.95706

THE RENOLDS NO. IS 0.53113995E 03 .
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THE AGE OF FLOW IS    1.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  12 .

AT      4.700  FEET, THE PRESSURE GRADIENT IS 0.0010836 LB/SQ IN/FT.

 RADIAL                                    RADIAL      AGE AT CENTRE
INCREMENT      RADIUS      VELOCITY    INCREMENT FLOW  OF INCREMENT
   NO.         (FT)        (FT/SEC)      (CU FT/SEC)       (MIN)

               0.50000     0.00000
    1                                    0.0052759          10.7970
               0.48191     0.19260
    2                                    0.0154927          10.2538
               0.46462     0.41337
    3                                    0.0251661          10.1522
               0.44752     0.61146
    4                                    0.0342811          10.1113
               0.42987     0.79592
    5                                    0.0428171          10.0890
               0.41151     0.96747
    6                                    0.0507523          10.0751
               0.39233     1.12604
    7                                    0.0580688          10.0656
               0.37218     1.27146
    8                                    0.0647604          10.0588
               0.35089     1.40380
    9                                    0.0708180          10.0538
               0.32822     1.52271
   10                                    0.0762199          10.0499
               0.30387     1.62776
   11                                    0.0809417          10.0470
               0.27740     1.71842
   12                                    0.0849569          10.0448
               0.24812     1.79415
   13                                    0.0882575          10.0431
               0.21489     1.85513
   14                                    0.0908484          10.0419
               0.17548     1.90123
   15                                    0.0927242          10.0410
               0.12412     1.93175
   16                                    0.0933690          10.0404
               0.00000     1.95524

THE RENOLDS NO. IS 0.53169151E 03 .
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THE AGE OF FLOW IS    1.0000  MIN.


THE INCREMENT NUMBER IN LENGTH IS  13 .


AT      6.300  FEET, THE PRESSURE GRADIENT IS 0.0011364 LB/SQ IN/FT.


 RADIAL                                           RADIAL       AGE AT CENTRE
INCREMENT      RADIUS        VELOCITY       INCREMENT FLOW  OF INCREMENT
   NO.          (FT)         (FT/SEC)        (CU FT/SEC)        (MIN)

              0.50000       0.00000
    1                                        0.0052759          1.0000
              0.47521       0.14255
    2                                        0.0154927         10.3472
              0.45577       0.41190
    3                                        0.0251661         10.2039
              0.43855       0.62638
    4                                        0.0342811         10.1487
              0.42106       0.82283
    5                                        0.0428171         10.1187
              0.40298       1.00445
    6                                        0.0507523         10.1000
              0.38414       1.17190
    7                                        0.0580688         10.0873
              0.36438       1.32519
    8                                        0.0647604         10.0783
              0.34352       1.46444
    9                                        0.0708180         10.0716
              0.32133       1.58955
   10                                        0.0762199         10.0665
              0.29752       1.70009
   11                                        0.0809417         10.0626
              0.27164       1.79554
   12                                        0.0849569         10.0596
              0.24303       1.87530
   13                                        0.0882575         10.0574
              0.21058       1.93937
   14                                        0.0908484         10.0558
              0.17214       1.98779
   15                                        0.0927242         10.0546
              0.12213       2.01988
   16                                        0.0933690         10.0538
              0.00000       2.04375


THE RENOLDS NO. IS 0.50700501E 03 .
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THE AGE OF FLOW IS    1.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  14 .

AT      9.500  FEET, THE PRESSURE GRADIENT IS 0.0012227 LB/SQ IN/FT.

 RADIAL                                         RADIAL       AGE AT CENTRE
INCREMENT       RADIUS        VELOCITY    INCREMENT FLOW   OF INCREMENT
   NO.           (FT)         (FT/SEC)     (CU FT/SEC)         (MIN)

               0.50000        0.00000
   1                                        0.0052759           1.0000
               0.46271        0.09732
   2                                        0.0154927          10.5489
               0.44149        0.42726
   3                                        0.0251661          10.3034
               0.42457        0.66186
   4                                        0.0342811          10.2197
               0.40754        0.87464
   5                                        0.0428171          10.1750
               0.39001        1.07084
   6                                        0.0507523          10.1473
               0.37178        1.25161
   7                                        0.0580688          10.1285
               0.35268        1.41714
   8                                        0.0647604          10.1151
               0.33255        1.56730
   9                                        0.0708180          10.1052
               0.31115        1.70221
  10                                        0.0762199          10.0977
               0.28820        1.82156
  11                                        0.0809417          10.0920
               0.26329        1.92479
  12                                        0.0849569          10.0876
               0.23579        2.01126
  13                                        0.0882575          10.0843
               0.20464        2.08057
  14                                        0.0908484          10.0819
               0.16783        2.13301
  15                                        0.0927242          10.0803
               0.12025        2.16795
  16                                        0.0933690          10.0790
               0.00000        2.19288

THE RENOLDS NO. IS 0.47122401E 03 .
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THE AGE OF FLOW IS    1.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  15 .

AT     12.700  FEET, THE PRESSURE GRADIENT IS 0.0012454 LB/SQ IN/FT.

 RADIAL                                                  RADIAL         AGE AT CENTRE
INCREMENT            RADIUS           VELOCITY       INCREMENT FLOW   OF INCREMENT
   NO.                (FT)            (FT/SEC)        (CU FT/SEC)         (MIN)

                     0.50000          0.00000
    1                                                  0.0052759             1.0000
                     0.46381          0.10002
    2                                                  0.0154927            10.7670
                     0.44036          0.38659
    3                                                  0.0251661            10.4032
                     0.42231          0.64697
    4                                                  0.0342811            10.2891
                     0.40493          0.87166
    5                                                  0.0428171            10.2296
                     0.38726          1.07583
    6                                                  0.0507523            10.1929
                     0.36899          1.26270
    7                                                  0.0580688            10.1682
                     0.34992          1.43318
    8                                                  0.0647604            10.1506
                     0.32984          1.58746
    9                                                  0.0708180            10.1376
                     0.30853          1.72578
   10                                                  0.0762199            10.1277
                     0.28568          1.84800
   11                                                  0.0809417            10.1202
                     0.26088          1.95362
   12                                                  0.0849569            10.1145
                     0.23351          2.04199
   13                                                  0.0882575            10.1102
                     0.20250          2.11268
   14                                                  0.0908484            10.1070
                     0.16581          2.16602
   15                                                  0.0927242            10.1048
                     0.11826          2.20140
   16                                                  0.0933690            10.1033
                     0.00000          2.22600

THE RENOLDS NO. IS 0.46261030E 03 .
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THE AGE OF FLOW IS    1.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  16 .

AT     19.100  FEET, THE PRESSURE GRADIENT IS 0.0012999 LB/SQ IN/FT.

 RADIAL                                    RADIAL      AGE AT CENTRE
INCREMENT      RADIUS      VELOCITY     INCREMENT FLOW OF INCREMENT
   NO.          (FT)       (FT/SEC)      (CU FT/SEC)        (MIN)

               0.50000     0.00000
    1                                    0.0052759            1.0000
               0.46622     0.10659
    2                                    0.0154927            1.0000
               0.43681     0.30209
    3                                    0.0251661           10.6220
               0.41629     0.62383
    4                                    0.0342811           10.4300
               0.39843     0.87249
    5                                    0.0428171           10.3382
               0.38065     1.09287
    6                                    0.0507523           10.2829
               0.36244     1.29239
    7                                    0.0580688           10.2461
               0.34353     1.47342
    8                                    0.0647604           10.2200
               0.32368     1.63673
    9                                    0.0708180           10.2008
               0.30266     1.78265
   10                                    0.0762199           10.1863
               0.28014     1.91139
   11                                    0.0809417           10.1753
               0.25572     2.02252
   12                                    0.0849569           10.1668
               0.22876     2.11544
   13                                    0.0882575           10.1605
               0.19822     2.18953
   14                                    0.0908484           10.1559
               0.16206     2.24523
   15                                    0.0927242           10.1527
               0.11506     2.28197
   16                                    0.0933690           10.1505
               0.00000     2.30634

THE RENOLDS NO. IS 0.44321858E 03 .
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THE AGE OF FLOW IS    1.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  17 .

AT     25.500  FEET, THE PRESSURE GRADIENT IS 0.0013842 LB/SQ IN/FT.

 RADIAL                                      RADIAL        AGE AT CENTRE
INCREMENT         RADIUS      VELOCITY   INCREMENT FLOW  OF INCREMENT
  NO.              (FT)       (FT/SEC)    (CU FT/SEC)        (MIN)

                 0.50000      0.00000
   1                                       0.0052759            1.0000
                 0.46941      0.11695
   2                                       0.0154927            1.0000
                 0.43429      0.22649
   3                                       0.0251661           10.8768
                 0.40931      0.56047
   4                                       0.0342811           10.5756
                 0.39003      0.86075
   5                                       0.0428171           10.4461
                 0.37189      1.11074
   6                                       0.0507523           10.3710
                 0.35366      1.33216
   7                                       0.0580688           10.3217
                 0.33491      1.53090
   8                                       0.0647604           10.2871
                 0.31534      1.70913
   9                                       0.0708180           10.2617
                 0.29469      1.86766
  10                                       0.0762199           10.2426
                 0.27262      2.00702
  11                                       0.0809417           10.2281
                 0.24871      2.12714
  12                                       0.0849569           10.2170
                 0.22235      2.22747
  13                                       0.0882575           10.2087
                 0.19249      2.30729
  14                                       0.0908484           10.2026
                 0.15711      2.36688
  15                                       0.0927242           10.1985
                 0.11101      2.40594
  16                                       0.0933690           10.1956
                 0.00000      2.43015

THE RENOLDS NO. IS 0.41623549E 03 .
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THE AGE OF FLOW IS    1.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  18 .

AT     38.300  FEET, THE PRESSURE GRADIENT IS 0.0014952 LB/SQ IN/FT.

 RADIAL                                          RADIAL        AGE AT CENTRE
INCREMENT         RADIUS        VELOCITY     INCREMENT FLOW   OF INCREMENT
   NO.             (FT)         (FT/SEC)      (CU FT/SEC)         (MIN)

                  0.50000       0.00000
    1                                          0.0052759           1.0000
                  0.47283       0.13075
    2                                          0.0154927           1.0000
                  0.44448       0.24622
    3                                          0.0251661           1.0000
                  0.41179       0.35533
    4                                          0.0342811          10.9221
                  0.38566       0.72293
    5                                          0.0428171          10.6736
                  0.36518       1.05413
    6                                          0.0507523          10.5477
                  0.34610       1.32342
    7                                          0.0580688          10.4700
                  0.32704       1.55686
    8                                          0.0647604          10.4170
                  0.30748       1.76245
    9                                          0.0708180          10.3787
                  0.28703       1.94342
   10                                          0.0762199          10.3502
                  0.26532       2.10114
   11                                          0.0809417          10.3286
                  0.24191       2.23643
   12                                          0.0849569          10.3123
                  0.21617       2.34916
   13                                          0.0882575          10.3001
                  0.18709       2.43870
   14                                          0.0908484          10.2912
                  0.15268       2.50499
   15                                          0.0927242          10.2852
                  0.10789       2.54826
   16                                          0.0933690          10.2811
                  0.00000       2.57365

THE RENOLDS NO. IS 0.38532238E 03 .
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THE AGE OF FLOW IS    1.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  19 .

AT     51.100  FEET, THE PRESSURE GRADIENT IS 0.0015976 LB/SQ IN/FT.

 RADIAL                                           RADIAL        AGE AT CENTRE
INCREMENT        RADIUS        VELOCITY      INCREMENT FLOW    OF INCREMENT
   NO.            (FT)         (FT/SEC)       (CU FT/SEC)          (MIN)

                0.50000        0.00000
   1                                          0.0052759           1.0000
                0.47542        0.14369
   2                                          0.0154927           1.0000
                0.44993        0.27210
   3                                          0.0251661           1.0000
                0.42229        0.38991
   4                                          0.0342811           1.0000
                0.39115        0.49843
   5                                          0.0428171          10.9466
                0.36448        0.88492
   6                                          0.0507523          10.7366
                0.34295        1.23924
   7                                          0.0580688          10.6207
                0.32289        1.52293
   8                                          0.0647604          10.5457
                0.30288        1.76445
   9                                          0.0708180          10.4930
                0.28229        1.97322
  10                                          0.0762199          10.4544
                0.26066        2.15318
  11                                          0.0809417          10.4254
                0.23749        2.30629
  12                                          0.0849569          10.4036
                0.21214        2.43336
  13                                          0.0882575          10.3874
                0.18359        2.53411
  14                                          0.0908484          10.3756
                0.14990        2.60825
  15                                          0.0927242          10.3677
                0.10618        2.65644
  16                                          0.0933690          10.3625
                0.00000        2.68389

THE RENOLDS NO. IS 0.36064397E 03 .
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THE AGE OF FLOW IS    1.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  20 .

AT      76.700  FEET, THE PRESSURE GRADIENT IS 0.0017728 LB/SQ IN/FT.

 RADIAL                                    RADIAL      AGE AT CENTRE
INCREMENT      RADIUS      VELOCITY    INCREMENT FLOW  OF INCREMENT
   NO.          (FT)       (FT/SEC)      (CU FT/SEC)        (MIN)

               0.50000     0.00000
    1                                    0.0052759            1.0000
               0.47902     0.16705
    2                                    0.0154927            1.0000
               0.45742     0.31826
    3                                    0.0251661            1.0000
               0.43437     0.45868
    4                                    0.0342811            1.0000
               0.40970     0.58725
    5                                    0.0428171            1.0000
               0.38312     0.70336
    6                                    0.0507523            1.0000
               0.35365     0.80761
    7                                    0.0580688           10.9803
               0.32616     1.20356
    8                                    0.0647604           10.8260
               0.30259     1.57946
    9                                    0.0708180           10.7294
               0.28024     1.87412
   10                                    0.0762199           10.6639
               0.25767     2.11640
   11                                    0.0809417           10.6168
               0.23407     2.31681
   12                                    0.0849569           10.5821
               0.20864     2.48012
   13                                    0.0882575           10.5566
               0.18029     2.60839
   14                                    0.0908484           10.5385
               0.14707     2.70175
   15                                    0.0927242           10.5264
               0.10413     2.76139
   16                                    0.0933690           10.5187
               0.00000     2.79310

THE RENOLDS NO. IS 0.32500016E 03 .
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THE AGE OF FLOW IS    1.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  21 .

AT    102.300  FEET, THE PRESSURE GRADIENT IS 0.0019379 LB/SQ IN/FT.

 RADIAL                                            RADIAL        AGE AT CENTRE
INCREMENT      RADIUS       VELOCITY         INCREMENT FLOW   OF INCREMENT
   NO.          (FT)        (FT/SEC)          (CU FT/SEC)         (MIN)

              0.50000      0.00000
    1                                          0.0052759              1.0000
              0.48168      0.19034
    2                                          0.0154927              1.0000
              0.46293      0.36456
    3                                          0.0251661              1.0000
              0.44315      0.52743
    4                                          0.0342811              1.0000
              0.42227      0.67801
    5                                          0.0428171              1.0000
              0.40011      0.81610
    6                                          0.0507523              1.0000
              0.37647      0.94141
    7                                          0.0580688              1.0000
              0.35102      1.05354
    8                                          0.0647604              1.0000
              0.32322      1.15199
    9                                          0.0708180              1.0000
              0.29372      1.35436
   10                                          0.0762199             10.9038
              0.26584      1.77073
   11                                          0.0809417             10.8220
              0.23942      2.07578
   12                                          0.0849569             10.7672
              0.21220      2.31092
   13                                          0.0882575             10.7286
              0.18264      2.48987
   14                                          0.0908484             10.7018
              0.14854      2.61786
   15                                          0.0927242             10.6842
              0.10484      2.69722
   16                                          0.0933690             10.6734
              0.00000      2.73585

THE RENOLDS NO. IS 0.29730186E 03 .
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THE AGE OF FLOW IS    1.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  22 .

AT    153.500  FEET, THE PRESSURE GRADIENT IS 0.0021408 LB/SQ IN/FT.

 RADIAL                                           RADIAL         AGE AT CENTRE
INCREMENT         RADIUS        VELOCITY     INCREMENT FLOW   OF INCREMENT
   NO.             (FT)        (FT/SEC)       (CU FT/SEC)         (MIN)

                  0.50000      0.00000
    1                                         0.0052759              1.0000
                  0.48412      0.22117
    2                                         0.0154927              1.0000
                  0.46810      0.42407
    3                                         0.0251661              1.0000
                  0.45138      0.61578
    4                                         0.0342811              1.0000
                  0.43393      0.79511
    5                                         0.0428171              1.0000
                  0.41569      0.96153
    6                                         0.0507523              1.0000
                  0.39655      1.11476
    7                                         0.0580688              1.0000
                  0.37638      1.25468
    8                                         0.0647604              1.0000
                  0.35500      1.38135
    9                                         0.0708180              1.0000
                  0.33221      1.49467
   10                                         0.0762199              1.0000
                  0.30767      1.59427
   11                                         0.0809417              1.0000
                  0.28094      1.67948
   12                                         0.0849569              1.0000
                  0.25133      1.74987
   13                                         0.0882575              1.0000
                  0.21765      1.80547
   14                                         0.0908484              1.0000
                  0.17759      1.84660
   15                                         0.0927242              1.0000
                  0.12525      1.87448
   16                                         0.0933690              1.0000
                  0.00000      1.88652

THE RENOLDS NO. IS 0.26912673E 03 .
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THE AGE OF FLOW IS    1.0000  MIN.

                DISTANCE FROM ENTRANCE          PRESSURE
                       (FEET)                  (LB/SQ IN)

                          0.000                  0.00000
                          0.100                  0.00031
                          0.300                  0.00092
                          0.700                  0.00216
                          1.500                  0.00462
                          3.100                  0.00689
                          6.300                  0.01039
                         12.700                  0.01815
                         25.500                  0.03485
                         51.100                  0.07309
                        102.300                  0.16377
                        204.700                  0.37953
                        409.500                  0.81797
                        819.100                  1.69485
                       1638.300                  3.44861
                       3276.700                  6.95614
                       6553.500                 13.97118
                      13107.100                 28.00128
                      26214.300                 56.06147
                      52428.699                112.18186
                     104857.498                224.42263
                     209715.096                448.90418
                     419430.293                897.86727
                     528000.000               1130.29578

WITH  528000.0  FT., THE DROP IN PRESSURE IS 1130.2958  LB/SQ IN.
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THE AGE OF FLOW IS    2.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  11 .

AT      3.100  FEET, THE PRESSURE GRADIENT IS 0.0010810 LB/SQ IN/FT.

 RADIAL                                          RADIAL        AGE AT CENTRE
INCREMENT      RADIUS        VELOCITY       INCREMENT FLOW   OF INCREMENT
   NO.          (FT)        (FT/SEC)         (CU FT/SEC)         (MIN)

              0.50000       0.00000
    1                                        0.0052759           10.4763
              0.48226       0.19625
    2                                        0.0154927           10.1628
              0.46514       0.41353
    3                                        0.0251661           10.1003
              0.44804       0.61049
    4                                        0.0342811           10.0737
              0.43039       0.79419
    5                                        0.0428171           10.0591
              0.41202       0.96513
    6                                        0.0507523           10.0498
              0.39282       1.12319
    7                                        0.0580688           10.0436
              0.37265       1.26817
    8                                        0.0647604           10.0391
              0.35132       1.40012
    9                                        0.0708180           10.0357
              0.32863       1.51871
   10                                        0.0762199           10.0332
              0.30425       1.62346
   11                                        0.0809417           10.0313
              0.27774       1.71387
   12                                        0.0849569           10.0298
              0.24842       1.78941
   13                                        0.0882575           10.0287
              0.21514       1.85024
   14                                        0.0908484           10.0279
              0.17568       1.89622
   15                                        0.0927242           10.0273
              0.12425       1.92666
   16                                        0.0933690           10.0269
              0.00000       1.95013

THE RENOLDS NO. IS 0.53296310E 03 .
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THE AGE OF FLOW IS    2.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  12 .

AT      4.700  FEET, THE PRESSURE GRADIENT IS 0.0010802 LB/SQ IN/FT.

 RADIAL                                    RADIAL      AGE AT CENTRE
INCREMENT      RADIUS      VELOCITY    INCREMENT FLOW  OF INCREMENT
   NO.          (FT)       (FT/SEC)      (CU FT/SEC)        (MIN)

               0.50000     0.00000
    1                                    0.0052759           10.7581
               0.48229     0.19660
    2                                    0.0154927           10.2503
               0.46518     0.41396
    3                                    0.0251661           10.1521
               0.44809     0.61084
    4                                    0.0342811           10.1115
               0.43043     0.79444
    5                                    0.0428171           10.0893
               0.41207     0.96529
    6                                    0.0507523           10.0753
               0.39287     1.12326
    7                                    0.0580688           10.0658
               0.37270     1.26815
    8                                    0.0647604           10.0590
               0.35137     1.40001
    9                                    0.0708180           10.0540
               0.32867     1.51852
   10                                    0.0762199           10.0501
               0.30429     1.62321
   11                                    0.0809417           10.0472
               0.27778     1.71356
   12                                    0.0849569           10.0450
               0.24845     1.78903
   13                                    0.0882575           10.0433
               0.21517     1.84981
   14                                    0.0908484           10.0421
               0.17569     1.89575
   15                                    0.0927242           10.0412
               0.12425     1.92617
   16                                    0.0933690           10.0406
               0.00000     1.94964

THE RENOLDS NO. IS 0.53337272E 03 .
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THE AGE OF FLOW IS    2.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  13 .

AT      6.300  FEET, THE PRESSURE GRADIENT IS 0.0010794 LB/SQ IN/FT.

 RADIAL                                    RADIAL      AGE AT CENTRE
INCREMENT      RADIUS      VELOCITY    INCREMENT FLOW  OF INCREMENT
   NO.          (FT)       (FT/SEC)      (CU FT/SEC)       (MIN)

               0.50000     0.00000
    1                                    0.0052759          11.0393
               0.48231     0.19686
    2                                    0.0154927          10.3377
               0.46522     0.41420
    3                                    0.0251661          10.2039
               0.44814     0.61098
    4                                    0.0342811          10.1493
               0.43049     0.79447
    5                                    0.0428171          10.1195
               0.41212     0.96522
    6                                    0.0507523          10.1008
               0.39292     1.12310
    7                                    0.0580688          10.0881
               0.37275     1.26791
    8                                    0.0647604          10.0790
               0.35143     1.39970
    9                                    0.0708180          10.0722
               0.32873     1.51814
   10                                    0.0762199          10.0671
               0.30434     1.62276
   11                                    0.0809417          10.0632
               0.27782     1.71304
   12                                    0.0849569          10.0602
               0.24850     1.78845
   13                                    0.0882575          10.0579
               0.21521     1.84918
   14                                    0.0908484          10.0563
               0.17572     1.89509
   15                                    0.0927242          10.0552
               0.12426     1.92549
   16                                    0.0933690          10.0543
               0.00000     1.94896

THE RENOLDS NO. IS 0.53378570E 03 .
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THE AGE OF FLOW IS    2.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  14 .

AT      9.500  FEET, THE PRESSURE GRADIENT IS 0.0010779 LB/SQ IN/FT.

 RADIAL                                         RADIAL        AGE AT CENTRE
INCREMENT      RADIUS        VELOCITY      INCREMENT FLOW  OF INCREMENT
  NO.           (FT)        (FT/SEC)        (CU FT/SEC)        (MIN)

               0.50000       0.00000
   1                                        0.0052759             11.6002
               0.48235       0.19725
   2                                        0.0154927             10.5121
               0.46527       0.41463
   3                                        0.0251661             10.3073
               0.44821       0.61125
   4                                        0.0342811             10.2249
               0.43057       0.79458
   5                                        0.0428171             10.1799
               0.41221       0.96517
   6                                        0.0507523             10.1517
               0.39301       1.12291
   7                                        0.0580688             10.1326
               0.37284       1.26760
   8                                        0.0647604             10.1189
               0.35151       1.39927
   9                                        0.0708180             10.1087
               0.32881       1.51758
  10                                        0.0762199             10.1010
               0.30442       1.62208
  11                                        0.0809417             10.0951
               0.27790       1.71224
  12                                        0.0849569             10.0906
               0.24856       1.78754
  13                                        0.0882575             10.0872
               0.21526       1.84818
  14                                        0.0908484             10.0847
               0.17577       1.89403
  15                                        0.0927242             10.0830
               0.12429       1.92439
  16                                        0.0933690             10.0818
               0.00000       1.94787

THE RENOLDS NO. IS 0.53453618E 03 .
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THE AGE OF FLOW IS    2.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  15 .

AT     12.700  FEET, THE PRESSURE GRADIENT IS 0.0011155 LB/SQ IN/FT.

 RADIAL                                          RADIAL       AGE AT CENTRE
INCREMENT      RADIUS      VELOCITY       INCREMENT FLOW   OF INCREMENT
   NO.          (FT)       (FT/SEC)        (CU FT/SEC)         (MIN)

              0.50000      0.00000
    1                                      0.0052759            2.0000
              0.47766      0.15740
    2                                      0.0154927           10.6945
              0.45889      0.41165
    3                                      0.0251661           10.4106
              0.44170      0.62087
    4                                      0.0342811           10.2999
              0.42415      0.81321
    5                                      0.0428171           10.2396
              0.40598      0.99127
    6                                      0.0507523           10.2020
              0.38702      1.15555
    7                                      0.0580688           10.1765
              0.36712      1.30600
    8                                      0.0647604           10.1582
              0.34611      1.44273
    9                                      0.0708180           10.1446
              0.32376      1.56556
   10                                      0.0762199           10.1344
              0.29975      1.67404
   11                                      0.0809417           10.1265
              0.27367      1.76767
   12                                      0.0849569           10.1206
              0.24482      1.84585
   13                                      0.0882575           10.1160
              0.21209      1.90869
   14                                      0.0908484           10.1127
              0.17329      1.95620
   15                                      0.0927242           10.1105
              0.12279      1.98767
   16                                      0.0933690           10.1088
              0.00000      2.01143

THE RENOLDS NO. IS 0.51651078E 03 .
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THE AGE OF FLOW IS    2.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  16 .

AT     19.100  FEET, THE PRESSURE GRADIENT IS 0.0011570 LB/SQ IN/FT.

 RADIAL                                        RADIAL        AGE AT CENTRE
INCREMENT      RADIUS        VELOCITY     INCREMENT FLOW   OF INCREMENT
   NO.          (FT)         (FT/SEC)      (CU FT/SEC)        (MIN)

              0.50000       0.00000
    1                                       0.0052759            2.0000
              0.47172       0.12590
    2                                       0.0154927           11.0879
              0.45160       0.41632
    3                                       0.0251661           10.6151
              0.43447       0.63709
    4                                       0.0342811           10.4465
              0.41712       0.83823
    5                                       0.0428171           10.3560
              0.39920       1.02388
    6                                       0.0507523           10.2997
              0.38054       1.19495
    7                                       0.0580688           10.2616
              0.36098       1.35156
    8                                       0.0647604           10.2344
              0.34033       1.49374
    9                                       0.0708180           10.2142
              0.31838       1.62146
   10                                       0.0762199           10.1990
              0.29481       1.73429
   11                                       0.0809417           10.1873
              0.26921       1.83172
   12                                       0.0849569           10.1785
              0.24091       1.91312
   13                                       0.0882575           10.1718
              0.20883       1.97842
   14                                       0.0908484           10.1669
              0.17083       2.02779
   15                                       0.0927242           10.1635
              0.12148       2.06056
   16                                       0.0933690           10.1610
              0.00000       2.08475

THE RENOLDS NO. IS 0.49797727E 03 .
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THE AGE OF FLOW IS    2.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  17 .

AT     25.500  FEET, THE PRESSURE GRADIENT IS 0.0011734 LB/SQ IN/FT.

 RADIAL                                      RADIAL         AGE AT CENTRE
INCREMENT      RADIUS      VELOCITY     INCREMENT FLOW   OF INCREMENT
   NO.          (FT)       (FT/SEC)      (CU FT/SEC)         (MIN)

              0.50000      0.00000
    1                                     0.0052759            2.0000
              0.47234      0.12850
    2                                     0.0154927           11.5047
              0.45078      0.38311
    3                                     0.0251661           10.8213
              0.43272      0.62360
    4                                     0.0342811           10.5913
              0.41508      0.83409
    5                                     0.0428171           10.4702
              0.39705      1.02605
    6                                     0.0507523           10.3953
              0.37836      1.20196
    7                                     0.0580688           10.3449
              0.35882      1.36250
    8                                     0.0647604           10.3089
              0.33823      1.50792
    9                                     0.0708180           10.2823
              0.31635      1.63835
   10                                     0.0762199           10.2621
              0.29288      1.75347
   11                                     0.0809417           10.2467
              0.26739      1.85279
   12                                     0.0849569           10.2350
              0.23923      1.93571
   13                                     0.0882575           10.2262
              0.20730      2.00209
   14                                     0.0908484           10.2197
              0.16946      2.05223
   15                                     0.0927242           10.2153
              0.12026      2.08543
   16                                     0.0933690           10.2120
              0.00000      2.10954

THE RENOLDS NO. IS 0.49099204E 03 .
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THE AGE OF FLOW IS    2.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  18 .

AT     38.300  FEET, THE PRESSURE GRADIENT IS 0.0012078 LB/SQ IN/FT.

 RADIAL                                     RADIAL      AGE AT CENTRE
INCREMENT      RADIUS      VELOCITY     INCREMENT FLOW  OF INCREMENT
   NO.         (FT)        (FT/SEC)      (CU FT/SEC)        (MIN)

               0.50000     0.00000
    1                                     0.0052759            2.0000
               0.47354     0.13402
    2                                     0.0154927            2.0000
               0.44873     0.31907
    3                                     0.0251661           11.2655
               0.42872     0.60296
    4                                     0.0342811           10.8850
               0.41062     0.83120
    5                                     0.0428171           10.6984
               0.39245     1.03503
    6                                     0.0507523           10.5851
               0.37377     1.22010
    7                                     0.0580688           10.5094
               0.35432     1.38821
    8                                     0.0647604           10.4557
               0.33388     1.53997
    9                                     0.0708180           10.4161
               0.31220     1.67578
   10                                     0.0762199           10.3862
               0.28896     1.79546
   11                                     0.0809417           10.3634
               0.26374     1.89860
   12                                     0.0849569           10.3460
               0.23588     1.98461
   13                                     0.0882575           10.3330
               0.20428     2.05326
   14                                     0.0908484           10.3234
               0.16683     2.10497
   15                                     0.0927242           10.3169
               0.11806     2.13911
   16                                     0.0933690           10.3122
               0.00000     2.16315

THE RENOLDS NO. IS 0.47701807E 03 .
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THE AGE OF FLOW IS    2.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  19 .

AT     51.100  FEET, THE PRESSURE GRADIENT IS 0.0012543 LB/SQ IN/FT.

 RADIAL                                        RADIAL        AGE AT CENTRE
INCREMENT       RADIUS       VELOCITY     INCREMENT FLOW   OF INCREMENT
   NO.           (FT)        (FT/SEC)      (CU FT/SEC)        (MIN)

               0.50000      0.00000
    1                                      0.0052759           2.0000
               0.47503      0.14151
    2                                      0.0154927           2.0000
               0.44814      0.27183
    3                                      0.0251661          11.7636
               0.42532      0.54967
    4                                      0.0342811          11.1893
               0.40603      0.81228
    5                                      0.0428171          10.9273
               0.38748      1.03585
    6                                      0.0507523          10.7731
               0.36869      1.23533
    7                                      0.0580688          10.6713
               0.34929      1.41496
    8                                      0.0647604          10.5996
               0.32899      1.57632
    9                                      0.0708180          10.5469
               0.30753      1.72014
   10                                      0.0762199          10.5072
               0.28458      1.84660
   11                                      0.0809417          10.4770
               0.25970      1.95544
   12                                      0.0849569          10.4541
               0.23226      2.04613
   13                                      0.0882575          10.4368
               0.20116      2.11830
   14                                      0.0908484          10.4243
               0.16432      2.17254
   15                                      0.0927242          10.4157
               0.11638      2.20830
   16                                      0.0933690          10.4095
               0.00000      2.23270

THE RENOLDS NO. IS 0.45933335E 03 .
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THE AGE OF FLOW IS    2.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  20 .

AT     76.700  FEET, THE PRESSURE GRADIENT IS 0.0013239 LB/SQ IN/FT.

 RADIAL                                          RADIAL       AGE AT CENTRE
INCREMENT        RADIUS       VELOCITY      INCREMENT FLOW  OF INCREMENT
  NO.             (FT)        (FT/SEC)       (CU FT/SEC)        (MIN)

                0.50000      0.00000
   1                                          0.0052759           2.0000
                0.47697      0.15290
   2                                          0.0154927           2.0000
                0.45316      0.29044
   3                                          0.0251661           2.0000
                0.42698      0.41962
   4                                          0.0342811          11.8804
                0.40330      0.71042
   5                                          0.0428171          11.4073
                0.38287      0.98832
   6                                          0.0507523          11.1528
                0.36329      1.22101
   7                                          0.0580688          10.9927
                0.34354      1.42494
   8                                          0.0647604          10.8824
                0.32315      1.60550
   9                                          0.0708180          10.8024
                0.30176      1.76492
  10                                          0.0762199          10.7427
                0.27900      1.90419
  11                                          0.0809417          10.6974
                0.25442      2.02352
  12                                          0.0849569          10.6632
                0.22736      2.12262
  13                                          0.0882575          10.6376
                0.19673      2.20103
  14                                          0.0908484          10.6190
                0.16045      2.25954
  15                                          0.0927242          10.6063
                0.11315      2.29788
  16                                          0.0933690          10.5974
                0.00000      2.32246

THE RENOLDS NO. IS 0.43519652E 03 .
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THE AGE OF FLOW IS    2.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  21 .

AT    102.300  FEET, THE PRESSURE GRADIENT IS 0.0013874 LB/SQ IN/FT.

 RADIAL                                            RADIAL       AGE AT CENTRE
INCREMENT        RADIUS       VELOCITY        INCREMENT FLOW   OF INCREMENT
   NO.            (FT)        (FT/SEC)          (CU FT/SEC)        (MIN)

                0.50000      0.00000
    1                                          0.0052759            2.0000
                0.47851      0.16331
    2                                          0.0154927            2.0000
                0.45638      0.31138
    3                                          0.0251661            2.0000
                0.43274      0.44866
    4                                          0.0342811            2.0000
                0.40702      0.57554
    5                                          0.0428171           11.9539
                0.38284      0.87031
    6                                          0.0507523           11.5546
                0.36142      1.15662
    7                                          0.0580688           11.3200
                0.34082      1.39404
    8                                          0.0647604           11.1649
                0.32002      1.59912
    9                                          0.0708180           11.0547
                0.29846      1.77775
   10                                          0.0762199           10.9734
                0.27571      1.93243
   11                                          0.0809417           10.9123
                0.25127      2.06419
   12                                          0.0849569           10.8663
                0.22447      2.17323
   13                                          0.0882575           10.8321
                0.19423      2.25919
   14                                          0.0908484           10.8073
                0.15849      2.32288
   15                                          0.0927242           10.7905
                0.11199      2.36453
   16                                          0.0933690           10.7789
                0.00000      2.39002

THE RENOLDS NO. IS 0.41526330E 03 .
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THE AGE OF FLOW IS    2.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  22 .

AT    153.500  FEET, THE PRESSURE GRADIENT IS 0.0015177 LB/SQ IN/FT.

 RADIAL                                         RADIAL        AGE AT CENTRE
INCREMENT      RADIUS       VELOCITY       INCREMENT FLOW   OF INCREMENT
   NO.          (FT)        (FT/SEC)        (CU FT/SEC)         (MIN)

               0.50000      0.00000
    1                                       0.0052759            2.0000
               0.48108      0.18454
    2                                       0.0154927            2.0000
               0.46174      0.35417
    3                                       0.0251661            2.0000
               0.44134      0.51333
    4                                       0.0342811            2.0000
               0.41980      0.66059
    5                                       0.0428171            2.0000
               0.39691      0.79532
    6                                       0.0507523            2.0000
               0.37235      0.91722
    7                                       0.0580688            2.0000
               0.34659      1.09820
    8                                       0.0647604           11.7849
               0.32191      1.41530
    9                                       0.0708180           11.5816
               0.29835      1.66621
   10                                       0.0762199           11.4430
               0.27443      1.87407
   11                                       0.0809417           11.3425
               0.24935      2.04653
   12                                       0.0849569           11.2684
               0.22228      2.18681
   13                                       0.0882575           11.2142
               0.19205      2.29621
   14                                       0.0908484           11.1755
               0.15656      2.37555
   15                                       0.0927242           11.1494
               0.11060      2.42676
   16                                       0.0933690           11.1322
               0.00000      2.45595

THE RENOLDS NO. IS 0.37961681E 03 .
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THE AGE OF FLOW IS    2.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  23 .

AT    204.700  FEET, THE PRESSURE GRADIENT IS 0.0016175 LB/SQ IN/FT.

 RADIAL                                       RADIAL       AGE AT CENTRE
INCREMENT        RADIUS        VELOCITY    INCREMENT FLOW  OF INCREMENT
   NO.            (FT)         (FT/SEC)     (CU FT/SEC)        (MIN)

                0.50000       0.00000
    1                                        0.0052759             2.0000
                0.48269       0.20103
    2                                        0.0154927             2.0000
                0.46505       0.38706
    3                                        0.0251661             2.0000
                0.44658       0.56261
    4                                        0.0342811             2.0000
                0.42724       0.72671
    5                                        0.0428171             2.0000
                0.40690       0.87858
    6                                        0.0507523             2.0000
                0.38542       1.01756
    7                                        0.0580688             2.0000
                0.36256       1.14315
    8                                        0.0647604             2.0000
                0.33804       1.25488
    9                                        0.0708180             2.0000
                0.31133       1.35296
   10                                        0.0762199            11.9697
                0.28354       1.59680
   11                                        0.0809417            11.8051
                0.25580       1.84303
   12                                        0.0849569            11.6878
                0.22700       2.03497
   13                                        0.0882575            11.6052
                0.19554       2.18108
   14                                        0.0908484            11.5478
                0.15912       2.28472
   15                                        0.0927242            11.5099
                0.11233       2.35000
   16                                        0.0933690            11.4857
                0.00000       2.38481

THE RENOLDS NO. IS 0.35620469E 03 .
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THE AGE OF FLOW IS    2.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  24 .

AT    307.100  FEET, THE PRESSURE GRADIENT IS 0.0017128 LB/SQ IN/FT.

 RADIAL                                    RADIAL      AGE AT CENTRE
INCREMENT      RADIUS      VELOCITY    INCREMENT FLOW  OF INCREMENT
   NO.          (FT)       (FT/SEC)      (CU FT/SEC)       (MIN)

               0.50000     0.00000
    1                                    0.0052759            2.0000
               0.48397     0.21786
    2                                    0.0154927            2.0000
               0.46775     0.41933
    3                                    0.0251661            2.0000
               0.45085     0.61042
    4                                    0.0342811            2.0000
               0.43324     0.79005
    5                                    0.0428171            2.0000
               0.41487     0.95778
    6                                    0.0507523            2.0000
               0.39564     1.11316
    7                                    0.0580688            2.0000
               0.37542     1.25549
    8                                    0.0647604            2.0000
               0.35403     1.38431
    9                                    0.0708180            2.0000
               0.33122     1.49920
   10                                    0.0762199            2.0000
               0.30669     1.59992
   11                                    0.0809417            2.0000
               0.27998     1.68647
   12                                    0.0849569            2.0000
               0.25040     1.75872
   13                                    0.0882575            2.0000
               0.21678     1.81701
   14                                    0.0908484            2.0000
               0.17687     1.86241
   15                                    0.0927242            2.0000
               0.12482     1.89435
   16                                    0.0933690            2.0000
               0.00000     1.90907

THE RENOLDS NO. IS 0.33638912E 03 .
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THE AGE OF FLOW IS    2.0000  MIN.

              DISTANCE FROM ENTRANCE          PRESSURE
                     (FEET)                  (LB/SQ IN)

                         0.000                0.00000
                         0.100                0.00031
                         0.300                0.00092
                         0.700                0.00216
                         1.500                0.00462
                         3.100                0.00689
                         6.300                0.01035
                        12.700                0.01729
                        25.500                0.03205
                        51.100                0.06302
                       102.300                0.13075
                       204.700                0.28564
                       409.500                0.63316
                       819.100                1.33471
                      1638.300                2.73780
                      3276.700                5.54398
                      6553.500               11.15634
                     13107.100               22.38106
                     26214.300               44.83050
                     52428.699               89.72939
                    104857.498              179.52715
                    209715.096              359.12269
                    419430.293              718.31377
                    528000.000              904.26724

WITH  528000.0  FT., THE DROP IN PRESSURE IS  904.2672  LB/SQ IN.
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THE AGE OF FLOW IS   10.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  16 .

AT     19.100  FEET, THE PRESSURE GRADIENT IS 0.0010587 LB/SQ IN/FT.

 RADIAL                                           RADIAL        AGE AT CENTRE
INCREMENT          RADIUS       VELOCITY     INCREMENT FLOW   OF INCREMENT
   NO.              (FT)        (FT/SEC)       (CU FT/SEC)        (MIN)

                   0.50000      0.00000
    1                                          0.0052759            12.8715
                   0.48402      0.21724
    2                                          0.0154927            10.9938
                   0.46779      0.41933
    3                                          0.0251661            10.6162
                   0.45089      0.60990
    4                                          0.0342811            10.4538
                   0.43327      0.78887
    5                                          0.0428171            10.3639
                   0.41487      0.95588
    6                                          0.0507523            10.3073
                   0.39560      1.11052
    7                                          0.0580688            10.2687
                   0.37532      1.25255
    8                                          0.0647604            10.2411
                   0.35388      1.38184
    9                                          0.0708180            10.2205
                   0.33104      1.49798
   10                                          0.0762199            10.2050
                   0.30650      1.60054
   11                                          0.0809417            10.1931
                   0.27980      1.68898
   12                                          0.0849569            10.1840
                   0.25026      1.76280
   13                                          0.0882575            10.1771
                   0.21673      1.82231
   14                                          0.0908484            10.1721
                   0.17694      1.86732
   15                                          0.0927242            10.1686
                   0.12507      1.89717
   16                                          0.0933690            10.1661
                   0.00000      1.92063

THE RENOLDS NO. IS 0.54421233E 03 .
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THE AGE OF FLOW IS   10.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  17 .

AT     25.500  FEET, THE PRESSURE GRADIENT IS 0.0010569 LB/SQ IN/FT.

 RADIAL                                         RADIAL         AGE AT CENTRE
INCREMENT        RADIUS          VELOCITY    INCREMENT FLOW   OF INCREMENT
   NO.            (FT)           (FT/SEC)     (CU FT/SEC)         (MIN)

                0.50000          0.00000
    1                                          0.0052759           13.8355
                0.48400          0.21685
    2                                          0.0154927           11.3267
                0.46776          0.41955
    3                                          0.0251661           10.8225
                0.45086          0.61031
    4                                          0.0342811           10.6057
                0.43325          0.78932
    5                                          0.0428171           10.4858
                0.41486          0.95632
    6                                          0.0507523           10.4103
                0.39560          1.11093
    7                                          0.0580688           10.3588
                0.37533          1.25293
    8                                          0.0647604           10.3219
                0.35389          1.38215
    9                                          0.0708180           10.2945
                0.33106          1.49822
   10                                          0.0762199           10.2737
                0.30652          1.60068
   11                                          0.0809417           10.2578
                0.27982          1.68901
   12                                          0.0849569           10.2457
                0.25028          1.76271
   13                                          0.0882575           10.2365
                0.21675          1.82213
   14                                          0.0908484           10.2298
                0.17695          1.86707
   15                                          0.0927242           10.2252
                0.12508          1.89689
   16                                          0.0933690           10.2218
                0.00000          1.92039

THE RENOLDS NO. IS 0.54512397E 03 .
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THE AGE OF FLOW IS   10.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  18 .

AT     38.300  FEET, THE PRESSURE GRADIENT IS 0.0010544 LB/SQ IN/FT.

 RADIAL                                     RADIAL      AGE AT CENTRE
INCREMENT      RADIUS      VELOCITY     INCREMENT FLOW  OF INCREMENT
   NO.         (FT)        (FT/SEC)      (CU FT/SEC)        (MIN)

               0.50000     0.00000
    1                                     0.0052759           15.7834
               0.48388     0.21520
    2                                     0.0154927           11.9954
               0.46759     0.41934
    3                                     0.0251661           11.2356
               0.45069     0.61078
    4                                     0.0342811           10.9097
               0.43308     0.79015
    5                                     0.0428171           10.7296
               0.41471     0.95736
    6                                     0.0507523           10.6162
               0.39546     1.11215
    7                                     0.0580688           10.5389
               0.37521     1.25428
    8                                     0.0647604           10.4835
               0.35378     1.38357
    9                                     0.0708180           10.4423
               0.33096     1.49962
   10                                     0.0762199           10.4111
               0.30644     1.60201
   11                                     0.0809417           10.3872
               0.27976     1.69022
   12                                     0.0849569           10.3690
               0.25024     1.76376
   13                                     0.0882575           10.3553
               0.21671     1.82306
   14                                     0.0908484           10.3452
               0.17694     1.86791
   15                                     0.0927242           10.3383
               0.12508     1.89773
   16                                     0.0933690           10.3332
               0.00000     1.92132

THE RENOLDS NO. IS 0.54641138E 03 .
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THE AGE OF FLOW IS   10.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  19 .

AT     51.100  FEET, THE PRESSURE GRADIENT IS 0.0010532 LB/SQ IN/FT.

 RADIAL                                       RADIAL       AGE AT CENTRE
INCREMENT       RADIUS       VELOCITY    INCREMENT FLOW  OF INCREMENT
   NO.           (FT)        (FT/SEC)      (CU FT/SEC)        (MIN)

                0.50000      0.00000
    1                                       0.0052759           17.7654
                0.48368      0.21255
    2                                       0.0154927           12.6690
                0.46728      0.41838
    3                                       0.0251661           11.6494
                0.45035      0.61088
    4                                       0.0342811           11.2139
                0.43275      0.79095
    5                                       0.0428171           10.9733
                0.41439      0.95869
    6                                       0.0507523           10.8219
                0.39515      1.11392
    7                                       0.0580688           10.7188
                0.37492      1.25642
    8                                       0.0647604           10.6448
                0.35352      1.38594
    9                                       0.0708180           10.5899
                0.33072      1.50217
   10                                       0.0762199           10.5483
                0.30622      1.60465
   11                                       0.0809417           10.5165
                0.27956      1.69287
   12                                       0.0849569           10.4923
                0.25007      1.76638
   13                                       0.0882575           10.4740
                0.21657      1.82565
   14                                       0.0908484           10.4606
                0.17682      1.87049
   15                                       0.0927242           10.4514
                0.12501      1.90032
   16                                       0.0933690           10.4445
                0.00000      1.92400

THE RENOLDS NO. IS 0.54704881E 03 .
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THE AGE OF FLOW IS   10.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  20 .

AT     76.700  FEET, THE PRESSURE GRADIENT IS 0.0010490 LB/SQ IN/FT.

 RADIAL                                    RADIAL       AGE AT CENTRE
INCREMENT      RADIUS      VELOCITY     INCREMENT FLOW  OF INCREMENT
   NO.          (FT)       (FT/SEC)      (CU FT/SEC)        (MIN)

               0.50000     0.00000
    1                                     0.0052759           10.0000
               0.48359     0.21185
    2                                     0.0154927           14.0110
               0.46710     0.41668
    3                                     0.0251661           12.4729
               0.45011     0.61019
    4                                     0.0342811           11.8192
               0.43249     0.79113
    5                                     0.0428171           11.4587
               0.41412     0.95961
    6                                     0.0507523           11.2319
               0.39489     1.11548
    7                                     0.0580688           11.0775
               0.37467     1.25843
    8                                     0.0647604           10.9667
               0.35329     1.38822
    9                                     0.0708180           10.8845
               0.33052     1.50456
   10                                     0.0762199           10.8222
               0.30604     1.60705
   11                                     0.0809417           10.7746
               0.27941     1.69516
   12                                     0.0849569           10.7384
               0.24993     1.76846
   13                                     0.0882575           10.7110
               0.21645     1.82757
   14                                     0.0908484           10.6910
               0.17673     1.87230
   15                                     0.0927242           10.6772
               0.12493     1.90214
   16                                     0.0933690           10.6668
               0.00000     1.92597

THE RENOLDS NO. IS 0.54926498E 03 .
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THE AGE OF FLOW IS   10.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  21 .

AT    102.300  FEET, THE PRESSURE GRADIENT IS 0.0010472 LB/SQ IN/FT.

 RADIAL                                          RADIAL        AGE AT CENTRE
INCREMENT          RADIUS       VELOCITY     INCREMENT FLOW   OF INCREMENT
   NO.              (FT)        (FT/SEC)      (CU FT/SEC)        (MIN)

                  0.50000      0.00000
    1                                          0.0052759           10.0000
                  0.48344      0.20954
    2                                          0.0154927           15.3753
                  0.46677      0.41274
    3                                          0.0251661           13.3063
                  0.44968      0.60788
    4                                          0.0342811           12.4287
                  0.43200      0.79040
    5                                          0.0428171           11.9460
                  0.41361      0.96026
    6                                          0.0507523           11.6427
                  0.39439      1.11737
    7                                          0.0580688           11.4363
                  0.37419      1.26132
    8                                          0.0647604           11.2884
                  0.35283      1.39186
    9                                          0.0708180           11.1787
                  0.33009      1.50876
   10                                          0.0762199           11.0957
                  0.30564      1.61160
   11                                          0.0809417           11.0323
                  0.27905      1.69990
   12                                          0.0849569           10.9841
                  0.24961      1.77327
   13                                          0.0882575           10.9477
                  0.21618      1.83243
   14                                          0.0908484           10.9209
                  0.17651      1.87719
   15                                          0.0927242           10.9026
                  0.12479      1.90711
   16                                          0.0933690           10.8887
                  0.00000      1.93113

THE RENOLDS NO. IS 0.55019418E 03 .
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THE AGE OF FLOW IS   10.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  22 .

AT    153.500  FEET, THE PRESSURE GRADIENT IS 0.0010423 LB/SQ IN/FT.

 RADIAL                                          RADIAL       AGE AT CENTRE
INCREMENT       RADIUS       VELOCITY      INCREMENT FLOW   OF INCREMENT
  NO.            (FT)        (FT/SEC)       (CU FT/SEC)        (MIN)

               0.50000       0.00000
   1                                        0.0052759          10.0000
               0.48343       0.20964
   2                                        0.0154927          18.1168
               0.46660       0.40676
   3                                        0.0251661          14.9806
               0.44928       0.60240
   4                                        0.0342811          13.6479
               0.43147       0.78707
   5                                        0.0428171          12.9186
               0.41300       0.95926
   6                                        0.0507523          12.4616
               0.39375       1.11860
   7                                        0.0580688          12.1512
               0.37355       1.26428
   8                                        0.0647604          11.9293
               0.35221       1.39610
   9                                        0.0708180          11.7649
               0.32951       1.51389
  10                                        0.0762199          11.6406
               0.30511       1.61731
  11                                        0.0809417          11.5458
               0.27856       1.70590
  12                                        0.0849569          11.4737
               0.24918       1.77934
  13                                        0.0882575          11.4194
               0.21580       1.83854
  14                                        0.0908484          11.3795
               0.17619       1.88335
  15                                        0.0927242          11.3520
               0.12453       1.91342
  16                                        0.0933690          11.3312
               0.00000       1.93776

THE RENOLDS NO. IS 0.55277032E 03 .
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THE AGE OF FLOW IS   10.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  23 .

AT    204.700  FEET, THE PRESSURE GRADIENT IS 0.0010389 LB/SQ IN/FT.

 RADIAL                                           RADIAL         AGE AT CENTRE
INCREMENT      RADIUS        VELOCITY       INCREMENT FLOW    OF INCREMENT
   NO.          (FT)         (FT/SEC)        (CU FT/SEC)          (MIN)

              0.50000       0.00000
    1                                        0.0052759            10.0000
              0.48336       0.20875
    2                                        0.0154927            10.0000
              0.46642       0.40324
    3                                        0.0251661            16.6743
              0.44892       0.59663
    4                                        0.0342811            14.8764
              0.43095       0.78281
    5                                        0.0428171            13.8946
              0.41239       0.95733
    6                                        0.0507523            13.2809
              0.39309       1.11912
    7                                        0.0580688            12.8652
              0.37289       1.26677
    8                                        0.0647604            12.5685
              0.35157       1.40010
    9                                        0.0708180            12.3493
              0.32889       1.51905
   10                                        0.0762199            12.1837
              0.30453       1.62328
   11                                        0.0809417            12.0575
              0.27803       1.71234
   12                                        0.0849569            11.9616
              0.24870       1.78605
   13                                        0.0882575            11.8895
              0.21539       1.84546
   14                                        0.0908484            11.8364
              0.17584       1.89045
   15                                        0.0927242            11.7999
              0.12428       1.92073
   16                                        0.0933690            11.7721
              0.00000       1.94542

THE RENOLDS NO. IS 0.55455625E 03 .
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THE AGE OF FLOW IS   10.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  24 .

AT    307.100  FEET, THE PRESSURE GRADIENT IS 0.0010342 LB/SQ IN/FT.

 RADIAL                                           RADIAL        AGE AT CENTRE
INCREMENT      RADIUS      VELOCITY         INCREMENT FLOW      OF INCREMENT
   NO.          (FT)       (FT/SEC)           (CU FT/SEC)           (MIN)

               0.50000     0.00000
    1                                         0.0052759           10.0000
               0.48325     0.20754
    2                                         0.0154927           10.0000
               0.46622     0.40046
    3                                         0.0251661           10.0000
               0.44846     0.58562
    4                                         0.0342811           17.3660
               0.43018     0.77244
    5                                         0.0428171           15.8618
               0.41140     0.95105
    6                                         0.0507523           14.9246
               0.39197     1.11774
    7                                         0.0580688           14.2928
               0.37172     1.26944
    8                                         0.0647604           13.8441
               0.35040     1.40607
    9                                         0.0708180           13.5137
               0.32775     1.52760
   10                                         0.0762199           13.2648
               0.30346     1.63375
   11                                         0.0809417           13.0757
               0.27705     1.72404
   12                                         0.0849569           12.9324
               0.24782     1.79854
   13                                         0.0882575           12.8247
               0.21462     1.85862
   14                                         0.0908484           12.7454
               0.17522     1.90416
   15                                         0.0927242           12.6908
               0.12386     1.93496
   16                                         0.0933690           12.6488
               0.00000     1.96038

THE RENOLDS NO. IS 0.55710531E 03 .
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THE AGE OF FLOW IS   10.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  25 .

AT    409.500  FEET, THE PRESSURE GRADIENT IS 0.0010307 LB/SQ IN/FT.

 RADIAL                                           RADIAL       AGE AT CENTRE
INCREMENT        RADIUS        VELOCITY      INCREMENT FLOW  OF INCREMENT
   NO.            (FT)         (FT/SEC)        (CU FT/SEC)       (MIN)

                 0.50000       0.00000
    1                                           0.0052759         10.0000
                 0.48318       0.20664
    2                                           0.0154927         10.0000
                 0.46606       0.39860
    3                                           0.0251661         10.0000
                 0.44818       0.58035
    4                                           0.0342811         19.8895
                 0.42966       0.76221
    5                                           0.0428171         17.8491
                 0.41064       0.94366
    6                                           0.0507523         16.5756
                 0.39108       1.11462
    7                                           0.0580688         15.7207
                 0.37075       1.27011
    8                                           0.0647604         15.1166
                 0.34941       1.40996
    9                                           0.0708180         14.6732
                 0.32678       1.53412
   10                                           0.0762199         14.3402
                 0.30252       1.64229
   11                                           0.0809417         14.0878
                 0.27617       1.73398
   12                                           0.0849569         13.8970
                 0.24702       1.80946
   13                                           0.0882575         13.7537
                 0.21391       1.87038
   14                                           0.0908484         13.6482
                 0.17464       1.91661
   15                                           0.0927242         13.5754
                 0.12344       1.94799
   16                                           0.0933690         13.5193
                 0.00000       1.97410

THE RENOLDS NO. IS 0.55900419E 03 .
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THE AGE OF FLOW IS   10.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  26 .

AT    614.300  FEET, THE PRESSURE GRADIENT IS 0.0010342 LB/SQ IN/FT.

 RADIAL                                                RADIAL       AGE AT CENTRE
INCREMENT          RADIUS         VELOCITY        INCREMENT FLOW   OF INCREMENT
   NO.              (FT)          (FT/SEC)         (CU FT/SEC)        (MIN)

                  0.50000         0.00000
    1                                               0.0052759          10.0000
                  0.48325         0.20755
    2                                               0.0154927          10.0000
                  0.46622         0.40044
    3                                               0.0251661          10.0000
                  0.44844         0.58297
    4                                               0.0342811          10.0000
                  0.42989         0.75409
    5                                               0.0428171          10.0000
                  0.41044         0.91336
    6                                               0.0507523          19.9367
                  0.39025         1.08669
    7                                               0.0580688          18.6044
                  0.36947         1.25421
    8                                               0.0647604          17.6687
                  0.34788         1.40426
    9                                               0.0708180          16.9884
                  0.32512         1.53693
   10                                               0.0762199          16.4810
                  0.30084         1.65198
   11                                               0.0809417          16.0987
                  0.27453         1.74890
   12                                               0.0849569          15.8112
                  0.24548         1.82828
   13                                               0.0882575          15.5957
                  0.21253         1.89240
   14                                               0.0908484          15.4369
                  0.17348         1.94112
   15                                               0.0927242          15.3273
                  0.12262         1.97424
   16                                               0.0933690          15.2420
                  0.00000         2.00187

THE RENOLDS NO. IS 0.55709016E 03 .
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THE AGE OF FLOW IS   10.0000  MIN.


THE INCREMENT NUMBER IN LENGTH IS  27 .


AT    819.100  FEET, THE PRESSURE GRADIENT IS 0.0010475 LB/SQ IN/FT.


 RADIAL                                               RADIAL        AGE AT CENTRE
INCREMENT          RADIUS        VELOCITY       INCREMENT FLOW   OF INCREMENT
   NO.              (FT)         (FT/SEC)         (CU FT/SEC)        (MIN)

                   0.50000       0.00000
    1                                              0.0052759          10.0000
                   0.48354       0.21098
    2                                              0.0154927          10.0000
                   0.46680       0.40734
    3                                              0.0251661          10.0000
                   0.44936       0.59336
    4                                              0.0342811          10.0000
                   0.43118       0.76797
    5                                              0.0428171          10.0000
                   0.41217       0.93061
    6                                              0.0507523          10.0000
                   0.39223       1.08080
    7                                              0.0580688          10.0000
                   0.37118       1.21850
    8                                              0.0647604          10.0000
                   0.34892       1.35443
    9                                              0.0708180          19.3402
                   0.32553       1.50326
   10                                              0.0762199          18.6360
                   0.30084       1.63123
   11                                              0.0809417          18.1114
                   0.27428       1.73836
   12                                              0.0849569          17.7198
                   0.24509       1.82526
   13                                              0.0882575          17.4274
                   0.21209       1.89525
   14                                              0.0908484          17.2123
                   0.17306       1.94841
   15                                              0.0927242          17.0638
                   0.12230       1.98434
   16                                              0.0933690          16.9480
                   0.00000       2.01383


THE RENOLDS NO. IS 0.55002389E 03 .
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THE AGE OF FLOW IS   10.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  28 .

AT   1228.700  FEET, THE PRESSURE GRADIENT IS 0.0010668 LB/SQ IN/FT.

 RADIAL                                          RADIAL        AGE AT CENTRE
INCREMENT         RADIUS        VELOCITY    INCREMENT FLOW   OF INCREMENT
   NO.             (FT)         (FT/SEC)     (CU FT/SEC)         (MIN)

                 0.50000        0.00000
    1                                          0.0052759          10.0000
                 0.48391        0.21619
    2                                          0.0154927          10.0000
                 0.46760        0.41744
    3                                          0.0251661          10.0000
                 0.45063        0.60846
    4                                          0.0342811          10.0000
                 0.43297        0.78812
    5                                          0.0428171          10.0000
                 0.41456        0.95586
    6                                          0.0507523          10.0000
                 0.39528        1.11120
    7                                          0.0580688          10.0000
                 0.37501        1.25385
    8                                          0.0647604          10.0000
                 0.35358        1.38379
    9                                          0.0708180          10.0000
                 0.33076        1.50060
   10                                          0.0762199          10.0000
                 0.30624        1.60382
   11                                          0.0809417          10.0000
                 0.27959        1.69294
   12                                          0.0849569          10.0000
                 0.25011        1.76742
   13                                          0.0882575          10.0000
                 0.21665        1.82747
   14                                          0.0908484          10.0000
                 0.17697        1.87290
   15                                          0.0927242          10.0000
                 0.12531        1.90301
   16                                          0.0933690          10.0000
                 0.00000        1.92654

THE RENOLDS NO. IS 0.54005294E 03 .
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THE AGE OF FLOW IS   10.0000  MIN.

               DISTANCE FROM ENTRANCE            PRESSURE
                      (FEET)                    (LB/SQ IN)

                         0.000                   0.00000
                         0.100                   0.00031
                         0.300                   0.00092
                         0.700                   0.00216
                         1.500                   0.00462
                         3.100                   0.00689
                         6.300                   0.01035
                        12.700                   0.01729
                        25.500                   0.03096
                        51.100                   0.05796
                       102.300                   0.11168
                       204.700                   0.21844
                       409.500                   0.43029
                       819.100                   0.85457
                      1638.300                   1.72589
                      3276.700                   3.47380
                      6553.500                   6.96964
                     13107.100                  13.96132
                     26214.300                  27.94466
                     52428.699                  55.91136
                    104857.498                 111.84475
                    209715.096                 223.71153
                    419430.293                 447.44510
                    528000.000                 563.27213

WITH  528000.0  FT., THE DROP IN PRESSURE IS  563.2721  LB/SQ IN.
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THE AGE OF FLOW IS   50.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  21 .

AT    102.300  FEET, THE PRESSURE GRADIENT IS 0.0010365 LB/SQ IN/FT.

 RADIAL                                    RADIAL        AGE AT CENTRE
INCREMENT      RADIUS      VELOCITY    INCREMENT FLOW  OF INCREMENT
   NO.          (FT)       (FT/SEC)     (CU FT/SEC)        (MIN)

               0.50000     0.00000
    1                                    0.0052759           24.9867
               0.48446     0.22305
    2                                    0.0154927           15.2849
               0.46836     0.41684
    3                                    0.0251661           13.3039
               0.45137     0.60778
    4                                    0.0342811           12.4339
               0.43371     0.78737
    5                                    0.0428171           11.9524
               0.41530     0.95488
    6                                    0.0507523           11.6490
               0.39603     1.10998
    7                                    0.0580688           11.4423
               0.37577     1.25214
    8                                    0.0647604           11.2941
               0.35434     1.38109
    9                                    0.0708180           11.1841
               0.33151     1.49657
   10                                    0.0762199           11.1008
               0.30697     1.59817
   11                                    0.0809417           11.0372
               0.28026     1.68540
   12                                    0.0849569           10.9888
               0.25070     1.75792
   13                                    0.0882575           10.9523
               0.21711     1.81643
   14                                    0.0908484           10.9254
               0.17725     1.86071
   15                                    0.0927242           10.9070
               0.12528     1.89036
   16                                    0.0933690           10.8930
               0.00000     1.91433

THE RENOLDS NO. IS 0.55585812E 03 .
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THE AGE OF FLOW IS   50.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  22 .

AT    153.500  FEET, THE PRESSURE GRADIENT IS 0.0010271 LB/SQ IN/FT.

 RADIAL                                              RADIAL       AGE AT CENTRE
INCREMENT        RADIUS         VELOCITY        INCREMENT FLOW   OF INCREMENT
   NO.            (FT)          (FT/SEC)         (CU FT/SEC)        (MIN)

                 0.50000        0.00000
    1                                             0.0052759            32.1700
                 0.48490        0.22965
    2                                             0.0154927            17.9218
                 0.46887        0.41143
    3                                             0.0251661            14.9757
                 0.45169        0.60174
    4                                             0.0342811            13.6592
                 0.43391        0.78249
    5                                             0.0428171            12.9323
                 0.41541        0.95149
    6                                             0.0507523            12.4751
                 0.39610        1.10804
    7                                             0.0580688            12.1640
                 0.37581        1.25116
    8                                             0.0647604            11.9413
                 0.35437        1.38072
    9                                             0.0708180            11.7763
                 0.33154        1.49649
   10                                             0.0762199            11.6515
                 0.30700        1.59813
   11                                             0.0809417            11.5562
                 0.28029        1.68515
   12                                             0.0849569            11.4837
                 0.25073        1.75737
   13                                             0.0882575            11.4291
                 0.21713        1.81564
   14                                             0.0908484            11.3890
                 0.17726        1.85977
   15                                             0.0927242            11.3613
                 0.12526        1.88947
   16                                             0.0933690            11.3403
                 0.00000        1.91375

THE RENOLDS NO. IS 0.56094179E 03 .
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THE AGE OF FLOW IS   50.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  23 .

AT    204.700  FEET, THE PRESSURE GRADIENT IS 0.0010159 LB/SQ IN/FT.

 RADIAL                                    RADIAL      AGE AT CENTRE
INCREMENT      RADIUS      VELOCITY    INCREMENT FLOW  OF INCREMENT
   NO.         (FT)        (FT/SEC)      (CU FT/SEC)       (MIN)

               0.50000     0.00000
    1                                    0.0052759           39.0036
               0.48541     0.23755
    2                                    0.0154927           20.5298
               0.46966     0.41145
    3                                    0.0251661           16.6629
               0.45242     0.59711
    4                                    0.0342811           14.8945
               0.43453     0.77734
    5                                    0.0428171           13.9176
               0.41595     0.94697
    6                                    0.0507523           13.3040
               0.39658     1.10428
    7                                    0.0580688           12.8873
               0.37626     1.24782
    8                                    0.0647604           12.5896
               0.35479     1.37754
    9                                    0.0708180           12.3692
               0.33194     1.49328
   10                                    0.0762199           12.2027
               0.30737     1.59468
   11                                    0.0809417           12.0758
               0.28064     1.68128
   12                                    0.0849569           11.9794
               0.25103     1.75308
   13                                    0.0882575           11.9067
               0.21740     1.81104
   14                                    0.0908484           11.8532
               0.17746     1.85496
   15                                    0.0927242           11.8164
               0.12539     1.88467
   16                                    0.0933690           11.7882
               0.00000     1.90926

THE RENOLDS NO. IS 0.56712463E 03 .
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THE AGE OF FLOW IS   50.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  24 .

AT    307.100  FEET, THE PRESSURE GRADIENT IS 0.0009956 LB/SQ IN/FT.

 RADIAL                                    RADIAL      AGE AT CENTRE
INCREMENT      RADIUS      VELOCITY    INCREMENT FLOW  OF INCREMENT
   NO.          (FT)       (FT/SEC)      (CU FT/SEC)       (MIN)

               0.50000     0.00000
    1                                    0.0052759           52.2270
               0.48571     0.24210
    2                                    0.0154927           25.6318
               0.47036     0.42216
    3                                    0.0251661           20.0236
               0.45335     0.59607
    4                                    0.0342811           17.3800
               0.43541     0.77235
    5                                    0.0428171           15.8995
               0.41676     0.94206
    6                                    0.0507523           14.9690
               0.39734     1.09971
    7                                    0.0580688           14.3389
               0.37697     1.24340
    8                                    0.0647604           13.8899
               0.35547     1.37308
    9                                    0.0708180           13.5583
               0.33259     1.48852
   10                                    0.0762199           13.3083
               0.30799     1.58934
   11                                    0.0809417           13.1181
               0.28122     1.67505
   12                                    0.0849569           12.9738
               0.25156     1.74609
   13                                    0.0882575           12.8650
               0.21786     1.80355
   14                                    0.0908484           12.7849
               0.17784     1.84718
   15                                    0.0927242           12.7296
               0.12565     1.87695
   16                                    0.0933690           12.6868
               0.00000     1.90218

THE RENOLDS NO. IS 0.57869086E 03 .
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THE AGE OF FLOW IS   50.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  25 .

AT    409.500  FEET, THE PRESSURE GRADIENT IS 0.0009751 LB/SQ IN/FT.

 RADIAL                                    RADIAL      AGE AT CENTRE
INCREMENT      RADIUS      VELOCITY    INCREMENT FLOW  OF INCREMENT
   NO.          (FT)       (FT/SEC)      (CU FT/SEC)       (MIN)

               0.50000     0.00000
    1                                    0.0052759           50.0000
               0.48557     0.23954
    2                                    0.0154927           30.6627
               0.47035     0.43201
    3                                    0.0251661           23.3338
               0.45369     0.60666
    4                                    0.0342811           19.8605
               0.43595     0.77725
    5                                    0.0428171           17.8854
               0.41740     0.94453
    6                                    0.0507523           16.6380
               0.39802     1.10008
    7                                    0.0580688           15.7943
               0.37768     1.24232
    8                                    0.0647604           15.1938
               0.35618     1.37078
    9                                    0.0708180           14.7510
               0.33329     1.48505
   10                                    0.0762199           14.4174
               0.30868     1.58462
   11                                    0.0809417           14.1641
               0.28186     1.66894
   12                                    0.0849569           13.9722
               0.25215     1.73911
   13                                    0.0882575           13.8275
               0.21838     1.79596
   14                                    0.0908484           13.7207
               0.17828     1.83922
   15                                    0.0927242           13.6469
               0.12599     1.86900
   16                                    0.0933690           13.5890
               0.00000     1.89481

THE RENOLDS NO. IS 0.59085607E 03 .
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THE AGE OF FLOW IS   50.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  26 .

AT    614.300  FEET, THE PRESSURE GRADIENT IS 0.0009414 LB/SQ IN/FT.

 RADIAL                                          RADIAL        AGE AT CENTRE
INCREMENT        RADIUS        VELOCITY     INCREMENT FLOW   OF INCREMENT
   NO.            (FT)         (FT/SEC)      (CU FT/SEC)         (MIN)

                0.50000        0.00000
    1                                        0.0052759           50.0000
                0.48509        0.23180
    2                                        0.0154927           40.7947
                0.46978        0.43945
    3                                        0.0251661           29.8308
                0.45343        0.62136
    4                                        0.0342811           24.7317
                0.43608        0.79382
    5                                        0.0428171           21.8067
                0.41783        0.95573
    6                                        0.0507523           19.9505
                0.39863        1.10604
    7                                        0.0580688           18.6931
                0.37839        1.24461
    8                                        0.0647604           17.7969
                0.35695        1.37022
    9                                        0.0708180           17.1359
                0.33408        1.48196
   10                                        0.0762199           16.6387
                0.30945        1.57904
   11                                        0.0809417           16.2622
                0.28260        1.66101
   12                                        0.0849569           15.9767
                0.25281        1.72993
   13                                        0.0882575           15.7608
                0.21894        1.78598
   14                                        0.0908484           15.6012
                0.17871        1.82881
   15                                        0.0927242           15.4903
                0.12624        1.85866
   16                                        0.0933690           15.4015
                0.00000        1.88547

THE RENOLDS NO. IS 0.61198454E 03 .
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THE AGE OF FLOW IS   50.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  27 .

AT    819.100  FEET, THE PRESSURE GRADIENT IS 0.0009226 LB/SQ IN/FT.

 RADIAL                                          RADIAL        AGE AT CENTRE
INCREMENT        RADIUS        VELOCITY     INCREMENT FLOW   OF INCREMENT
   NO.            (FT)         (FT/SEC)       (CU FT/SEC)        (MIN)

                 0.50000       0.00000
    1                                          0.0052759          50.0000
                 0.48465       0.22553
    2                                          0.0154927          50.9730
                 0.46908       0.43591
    3                                          0.0251661          36.2461
                 0.45273       0.62414
    4                                          0.0342811          29.5381
                 0.43548       0.79829
    5                                          0.0428171          25.6953
                 0.41732       0.96041
    6                                          0.0507523          23.2514
                 0.39820       1.11073
    7                                          0.0580688          21.5892
                 0.37803       1.24879
    8                                          0.0647604          20.4010
                 0.35664       1.37390
    9                                          0.0708180          19.5237
                 0.33381       1.48523
   10                                          0.0762199          18.8639
                 0.30921       1.58175
   11                                          0.0809417          18.3648
                 0.28238       1.66352
   12                                          0.0849569          17.9860
                 0.25263       1.73273
   13                                          0.0882575          17.6983
                 0.21880       1.78922
   14                                          0.0908484          17.4854
                 0.17863       1.83251
   15                                          0.0927242          17.3370
                 0.12625       1.86284
   16                                          0.0933690          17.2162
                 0.00000       1.89075

THE RENOLDS NO. IS 0.62451542E 03 .
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THE AGE OF FLOW IS   50.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  28 .

AT   1228.700  FEET, THE PRESSURE GRADIENT IS 0.0009017 LB/SQ IN/FT.

 RADIAL                                           RADIAL      AGE AT CENTRE
INCREMENT         RADIUS       VELOCITY     INCREMENT FLOW  OF INCREMENT
   NO.             (FT)        (FT/SEC)      (CU FT/SEC)        (MIN)

                 0.50000      0.00000
    1                                          0.0052759          50.0000
                 0.48420      0.21954
    2                                          0.0154927          50.0000
                 0.46819      0.42527
    3                                          0.0251661          49.1629
                 0.45158      0.62108
    4                                          0.0342811          39.1333
                 0.43424      0.79761
    5                                          0.0428171          33.4512
                 0.41604      0.96146
    6                                          0.0507523          29.8328
                 0.39690      1.11345
    7                                          0.0580688          27.3624
                 0.37672      1.25317
    8                                          0.0647604          25.5918
                 0.35535      1.37984
    9                                          0.0708180          24.2830
                 0.33254      1.49254
   10                                          0.0762199          23.2992
                 0.30798      1.59018
   11                                          0.0809417          22.5551
                 0.28120      1.67386
   12                                          0.0849569          21.9882
                 0.25152      1.74518
   13                                          0.0882575          21.5556
                 0.21780      1.80369
   14                                          0.0908484          21.2345
                 0.17779      1.84864
   15                                          0.0927242          21.0096
                 0.12567      1.88053
   16                                          0.0933690          20.8222
                 0.00000      1.91045

THE RENOLDS NO. IS 0.63895058E 03 .
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THE AGE OF FLOW IS   50.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  29 .

AT   1638.300  FEET, THE PRESSURE GRADIENT IS 0.0008900 LB/SQ IN/FT.

 RADIAL                                        RADIAL         AGE AT CENTRE
INCREMENT      RADIUS       VELOCITY      INCREMENT FLOW   OF INCREMENT
   NO.          (FT)        (FT/SEC)       (CU FT/SEC)         (MIN)

               0.50000      0.00000
    1                                       0.0052759          50.0000
               0.48394      0.21615
    2                                       0.0154927          50.0000
               0.46765      0.41854
    3                                       0.0251661          50.0000
               0.45077      0.61306
    4                                       0.0342811          48.7575
               0.43327      0.79526
    5                                       0.0428171          41.2030
               0.41499      0.96050
    6                                       0.0507523          36.4047
               0.39580      1.11322
    7                                       0.0580688          33.1227
               0.37557      1.25412
    8                                       0.0647604          30.7668
               0.35416      1.38240
    9                                       0.0708180          29.0237
               0.33133      1.49706
   10                                       0.0762199          27.7138
               0.30678      1.59702
   11                                       0.0809417          26.7220
               0.28003      1.68360
   12                                       0.0849569          25.9636
               0.25041      1.75748
   13                                       0.0882575          25.3831
               0.21680      1.81820
   14                                       0.0908484          24.9516
               0.17695      1.86493
   15                                       0.0927242          24.6482
               0.12505      1.89868
   16                                       0.0933690          24.3913
               0.00000      1.93062

THE RENOLDS NO. IS 0.64734293E 03 .
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THE AGE OF FLOW IS   50.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  30 .

AT   2457.500  FEET, THE PRESSURE GRADIENT IS 0.0008765 LB/SQ IN/FT.

 RADIAL                                        RADIAL        AGE AT CENTRE
INCREMENT      RADIUS       VELOCITY      INCREMENT FLOW   OF INCREMENT
   NO.          (FT)        (FT/SEC)       (CU FT/SEC)        (MIN)

               0.50000      0.00000
    1                                       0.0052759           50.0000
               0.48363      0.21222
    2                                       0.0154927           50.0000
               0.46702      0.41069
    3                                       0.0251661           50.0000
               0.44976      0.60029
    4                                       0.0342811           50.0000
               0.43185      0.78027
    5                                       0.0428171           56.8088
               0.41326      0.95351
    6                                       0.0507523           49.5756
               0.39391      1.11223
    7                                       0.0580688           44.6414
               0.37359      1.25621
    8                                       0.0647604           41.1011
               0.35211      1.38674
    9                                       0.0708180           38.4782
               0.32924      1.50463
   10                                       0.0762199           36.5018
               0.30468      1.60946
   11                                       0.0809417           34.9989
               0.27798      1.70126
   12                                       0.0849569           33.8442
               0.24849      1.77981
   13                                       0.0882575           32.9585
               0.21506      1.84458
   14                                       0.0908484           32.2992
               0.17549      1.89459
   15                                       0.0927242           31.8327
               0.12402      1.93161
   16                                       0.0933690           31.4279
               0.00000      1.96708

THE RENOLDS NO. IS 0.65735748E 03 .
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THE AGE OF FLOW IS   50.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  31 .

AT   3276.700  FEET, THE PRESSURE GRADIENT IS 0.0008696 LB/SQ IN/FT.

 RADIAL                                             RADIAL        AGE AT CENTRE
INCREMENT       RADIUS       VELOCITY         INCREMENT FLOW   OF INCREMENT
   NO.           (FT)        (FT/SEC)          (CU FT/SEC)         (MIN)

               0.50000      0.00000
    1                                          0.0052759           50.0000
               0.48347      0.21021
    2                                          0.0154927           50.0000
               0.46669      0.40679
    3                                          0.0251661           50.0000
               0.44925      0.59458
    4                                          0.0342811           50.0000
               0.43114      0.77268
    5                                          0.0428171           50.0000
               0.41229      0.94072
    6                                          0.0507523           50.0000
               0.39262      1.09844
    7                                          0.0580688           56.1855
               0.37205      1.25052
    8                                          0.0647604           51.4194
               0.35044      1.38734
    9                                          0.0708180           47.8948
               0.32750      1.51029
   10                                          0.0762199           45.2338
               0.30293      1.61986
   11                                          0.0809417           43.2031
               0.27628      1.71596
   12                                          0.0849569           41.6395
               0.24689      1.79837
   13                                          0.0882575           40.4391
               0.21362      1.86651
   14                                          0.0908484           39.5451
               0.17426      1.91930
   15                                          0.0927242           38.9092
               0.12313      1.95905
   16                                          0.0933690           38.3479
               0.00000      1.99740

THE RENOLDS NO. IS 0.66257145E 03 .
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THE AGE OF FLOW IS   50.0000  MIN.


THE INCREMENT NUMBER IN LENGTH IS  32 .


AT   4915.100  FEET, THE PRESSURE GRADIENT IS 0.0008674 LB/SQ IN/FT.


 RADIAL                                          RADIAL         AGE AT CENTRE
INCREMENT       RADIUS        VELOCITY     INCREMENT FLOW   OF INCREMENT
   NO.           (FT)         (FT/SEC)      (CU FT/SEC)         (MIN)

                0.50000       0.00000
   1                                         0.0052759            50.0000
                0.48341       0.20963
   2                                         0.0154927            50.0000
                0.46658       0.40559
   3                                         0.0251661            50.0000
                0.44908       0.59280
   4                                         0.0342811            50.0000
                0.43091       0.77032
   5                                         0.0428171            50.0000
                0.41200       0.93779
   6                                         0.0507523            50.0000
                0.39225       1.09492
   7                                         0.0580688            50.0000
                0.37155       1.24143
   8                                         0.0647604            50.0000
                0.34974       1.37700
   9                                         0.0708180            50.0000
                0.32660       1.50133
  10                                         0.0762199            50.0000
                0.30182       1.61393
  11                                         0.0809417            59.5391
                0.27502       1.71764
  12                                         0.0849569            57.1175
                0.24557       1.80812
  13                                         0.0882575            55.2563
                0.21235       1.88311
  14                                         0.0908484            53.8701
                0.17315       1.94150
  15                                         0.0927242            52.8763
                0.12232       1.98617
  16                                         0.0933690            51.9797
                0.00000       2.02947


THE RENOLDS NO. IS 0.66421258E 03 .
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THE AGE OF FLOW IS   50.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  33 .

AT   6553.500  FEET, THE PRESSURE GRADIENT IS 0.0008683 LB/SQ IN/FT.

 RADIAL                                           RADIAL        AGE AT CENTRE
INCREMENT         RADIUS        VELOCITY     INCREMENT FLOW   OF INCREMENT
   NO.             (FT)         (FT/SEC)       (CU FT/SEC)        (MIN)

                 0.50000        0.00000
    1                                            0.0052759            50.0000
                 0.48344        0.20983
    2                                            0.0154927            50.0000
                 0.46663        0.40609
    3                                            0.0251661            50.0000
                 0.44915        0.59353
    4                                            0.0342811            50.0000
                 0.43101        0.77130
    5                                            0.0428171            50.0000
                 0.41212        0.93901
    6                                            0.0507523            50.0000
                 0.39240        1.09639
    7                                            0.0580688            50.0000
                 0.37174        1.24311
    8                                            0.0647604            50.0000
                 0.34997        1.37892
    9                                            0.0708180            50.0000
                 0.32687        1.50348
   10                                            0.0762199            50.0000
                 0.30216        1.61632
   11                                            0.0809417            50.0000
                 0.27541        1.71671
   12                                            0.0849569            50.0000
                 0.24596        1.80391
   13                                            0.0882575            50.0000
                 0.21270        1.87689
   14                                            0.0908484            50.0000
                 0.17343        1.93412
   15                                            0.0927242            50.0000
                 0.12247        1.97803
   16                                            0.0933690            50.0000
                 0.00000        2.02072

THE RENOLDS NO. IS 0.66353555E 03 .
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THE AGE OF FLOW IS   50.0000  MIN.

                DISTANCE FROM ENTRANCE           PRESSURE
                        (FEET)                 (LB/SQ IN)

                               0.000            0.00000
                               0.100            0.00031
                               0.300            0.00092
                               0.700            0.00216
                               1.500            0.00462
                               3.100            0.00689
                               6.300            0.01035
                              12.700            0.01729
                              25.500            0.03096
                              51.100            0.05796
                             102.300            0.11159
                             204.700            0.21674
                             409.500            0.42063
                             819.100            0.80726
                            1638.300            1.54720
                            3276.700            2.98502
                            6553.500            5.82905
                           13107.100           11.51958
                           26214.300           22.90066
                           52428.699           45.66281
                          104857.498           91.18711
                          209715.096          182.23571
                          419430.293          364.33292
                          528000.000          458.60477

WITH  528000.0  FT., THE DROP IN PRESSURE IS  458.6048  LB/SQ IN.
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THE AGE OF FLOW IS  200.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  25 .

AT    409.500  FEET, THE PRESSURE GRADIENT IS 0.0009684 LB/SQ IN/FT.

 RADIAL                                          RADIAL        AGE AT CENTRE
INCREMENT        RADIUS        VELOCITY     INCREMENT FLOW   OF INCREMENT
   NO.            (FT)         (FT/SEC)       (CU FT/SEC)        (MIN)

                 0.50000       0.00000
    1                                           0.0052759          64.1110
                 0.48610       0.24846
    2                                           0.0154927          30.4022
                 0.47119       0.43428
    3                                           0.0251661          23.2938
                 0.45461       0.60713
    4                                           0.0342811          19.8550
                 0.43692       0.77651
    5                                           0.0428171          17.8901
                 0.41838       0.94221
    6                                           0.0507523          16.6470
                 0.39900       1.09621
    7                                           0.0580688          15.8052
                 0.37863       1.23710
    8                                           0.0647604          15.2054
                 0.35710       1.36437
    9                                           0.0708180          14.7628
                 0.33416       1.47757
   10                                           0.0762199          14.4293
                 0.30949       1.57621
   11                                           0.0809417          14.1760
                 0.28261       1.65975
   12                                           0.0849569          13.9839
                 0.25281       1.72935
   13                                           0.0882575          13.8390
                 0.21895       1.78576
   14                                           0.0908484          13.7321
                 0.17873       1.82869
   15                                           0.0927242          13.6581
                 0.12626       1.85829
   16                                           0.0933690          13.6001
                 0.00000       1.88404

THE RENOLDS NO. IS 0.59493288E 03 .
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THE AGE OF FLOW IS  200.0000  MIN.


THE INCREMENT NUMBER IN LENGTH IS  26 .


AT    614.300  FEET, THE PRESSURE GRADIENT IS 0.0009325 LB/SQ IN/FT.

  RADIAL                                            RADIAL        AGE AT CENTRE
INCREMENT          RADIUS        VELOCITY     INCREMENT FLOW   OF INCREMENT
   NO.              (FT)         (FT/SEC)       (CU FT/SEC)        (MIN)

                  0.50000        0.00000
    1                                            0.0052759             90.3283
                  0.48587        0.24465
    2                                            0.0154927             40.2356
                  0.47098        0.44229
    3                                            0.0251661             29.7486
                  0.45473        0.62123
    4                                            0.0342811             24.7156
                  0.43742        0.79171
    5                                            0.0428171             21.8131
                  0.41917        0.95146
    6                                            0.0507523             19.9674
                  0.39995        1.09987
    7                                            0.0580688             18.7146
                  0.37967        1.23670
    8                                            0.0647604             17.8205
                  0.35817        1.36072
    9                                            0.0708180             17.1604
                  0.33523        1.47102
   10                                            0.0762199             16.6636
                  0.31051        1.56680
   11                                            0.0809417             16.2871
                  0.28355        1.64772
   12                                            0.0849569             16.0015
                  0.25363        1.71587
   13                                            0.0882575             15.7852
                  0.21961        1.77131
   14                                            0.0908484             15.6254
                  0.17917        1.81366
   15                                            0.0927242             15.5142
                  0.12638        1.84324
   16                                            0.0933690             15.4250
                  0.00000        1.86987

THE RENOLDS NO. IS 0.61786775E 03 .
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THE AGE OF FLOW IS  200.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  27 .

AT    819.100  FEET, THE PRESSURE GRADIENT IS 0.0009105 LB/SQ IN/FT.

 RADIAL                                            RADIAL       AGE AT CENTRE
INCREMENT         RADIUS       VELOCITY      INCREMENT FLOW  OF INCREMENT
   NO.             (FT)        (FT/SEC)       (CU FT/SEC)        (MIN)

                  0.50000      0.00000
    1                                          0.0052759          116.9320
                  0.48579      0.24314
    2                                          0.0154927           50.0462
                  0.47086      0.44195
    3                                          0.0251661           36.1239
                  0.45468      0.62463
    4                                          0.0342811           29.5193
                  0.43747      0.79521
    5                                          0.0428171           25.7100
                  0.41930      0.95454
    6                                          0.0507523           23.2814
                  0.40015      1.10242
    7                                          0.0580688           21.6260
                  0.37991      1.23826
    8                                          0.0647604           20.4411
                  0.35845      1.36132
    9                                          0.0708180           19.5654
                  0.33553      1.47074
   10                                          0.0762199           18.9065
                  0.31082      1.56556
   11                                          0.0809417           18.4077
                  0.28386      1.64606
   12                                          0.0849569           18.0286
                  0.25395      1.71431
   13                                          0.0882575           17.7405
                  0.21994      1.77004
   14                                          0.0908484           17.5271
                  0.17956      1.81275
   15                                          0.0927242           17.3783
                  0.12690      1.84276
   16                                          0.0933690           17.2568
                  0.00000      1.87062

THE RENOLDS NO. IS 0.63277394E 03 .
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THE AGE OF FLOW IS  200.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  28 .

AT   1228.700  FEET, THE PRESSURE GRADIENT IS 0.0008826 LB/SQ IN/FT.

 RADIAL                                          RADIAL       AGE AT CENTRE
INCREMENT       RADIUS       VELOCITY      INCREMENT FLOW  OF INCREMENT
   NO.           (FT)        (FT/SEC)       (CU FT/SEC)        (MIN)

                0.50000      0.00000
    1                                        0.0052759           170.8321
                0.48566      0.24101
    2                                        0.0154927            69.7578
                0.47069      0.44279
    3                                        0.0251661            48.8527
                0.45453      0.62625
    4                                        0.0342811            39.1048
                0.43734      0.79555
    5                                        0.0428171            33.4996
                0.41916      0.95412
    6                                        0.0507523            29.9111
                0.39998      1.10177
    7                                        0.0580688            27.4530
                0.37972      1.23767
    8                                        0.0647604            25.6876
                0.35823      1.36090
    9                                        0.0708180            24.3809
                0.33527      1.47045
   10                                        0.0762199            23.3982
                0.31053      1.56531
   11                                        0.0809417            22.6537
                0.28354      1.64711
   12                                        0.0849569            22.0852
                0.25361      1.71686
   13                                        0.0882575            21.6508
                0.21961      1.77408
   14                                        0.0908484            21.3283
                0.17925      1.81804
   15                                        0.0927242            21.1020
                0.12667      1.84963
   16                                        0.0933690            20.9124
                0.00000      1.87946

THE RENOLDS NO. IS 0.65276529E 03 .
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THE AGE OF FLOW IS  200.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  29 .

AT   1638.300  FEET, THE PRESSURE GRADIENT IS 0.0008631 LB/SQ IN/FT.

 RADIAL                                                RADIAL      AGE AT CENTRE
INCREMENT          RADIUS        VELOCITY        INCREMENT FLOW   OF INCREMENT
   NO.              (FT)         (FT/SEC)         (CU FT/SEC)         (MIN)

                  0.50000        0.00000
    1                                              0.0052759          200.0000
                  0.48551        0.23664
    2                                              0.0154927           89.5252
                  0.47051        0.44236
    3                                              0.0251661           61.5347
                  0.45442        0.62702
    4                                              0.0342811           48.6586
                  0.43729        0.79645
    5                                              0.0428171           41.2769
                  0.41915        0.95277
    6                                              0.0507523           36.5407
                  0.39996        1.09843
    7                                              0.0580688           33.2842
                  0.37966        1.23335
    8                                              0.0647604           30.9389
                  0.35812        1.35639
    9                                              0.0708180           29.2005
                  0.33512        1.46635
   10                                              0.0762199           27.8924
                  0.31033        1.56235
   11                                              0.0809417           26.8993
                  0.28331        1.64605
   12                                              0.0849569           26.1374
                  0.25339        1.71754
   13                                              0.0882575           25.5535
                  0.21942        1.77631
   14                                              0.0908484           25.1193
                  0.17914        1.82156
   15                                              0.0927242           24.8132
                  0.12672        1.85483
   16                                              0.0933690           24.5515
                  0.00000        1.88676

THE RENOLDS NO. IS 0.66752172E 03 .
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THE AGE OF FLOW IS  200.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  30 .

AT   2457.500  FEET, THE PRESSURE GRADIENT IS 0.0008341 LB/SQ IN/FT.

 RADIAL                                             RADIAL       AGE AT CENTRE
INCREMENT          RADIUS        VELOCITY      INCREMENT FLOW  OF INCREMENT
  NO.               (FT)         (FT/SEC)       (CU FT/SEC)        (MIN)

                   0.50000       0.00000
   1                                              0.0052759         200.0000
                   0.48499       0.23065
   2                                              0.0154927         129.4989
                   0.46969       0.44112
   3                                              0.0251661          86.8686
                   0.45355       0.62980
   4                                              0.0342811          67.7032
                   0.43646       0.80108
   5                                              0.0428171          56.7898
                   0.41837       0.95825
   6                                              0.0507523          49.7853
                   0.39923       1.10284
   7                                              0.0580688          44.9505
                   0.37894       1.23561
   8                                              0.0647604          41.4547
                   0.35737       1.35689
   9                                              0.0708180          38.8531
                   0.33431       1.46677
  10                                              0.0762199          36.8869
                   0.30947       1.56491
  11                                              0.0809417          35.3853
                   0.28243       1.65112
  12                                              0.0849569          34.2268
                   0.25251       1.72501
  13                                              0.0882575          33.3368
                   0.21856       1.78598
  14                                              0.0908484          32.6739
                   0.17834       1.83303
  15                                              0.0927242          32.2022
                   0.12599       1.86903
  16                                              0.0933690          31.7860
                   0.00000       1.90407

THE RENOLDS NO. IS 0.69071072E 03 .
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THE AGE OF FLOW IS  200.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  31 .

AT   3276.700  FEET, THE PRESSURE GRADIENT IS 0.0008132 LB/SQ IN/FT.

 RADIAL                                            RADIAL       AGE AT CENTRE
INCREMENT        RADIUS        VELOCITY       INCREMENT FLOW   OF INCREMENT
  NO.             (FT)         (FT/SEC)        (CU FT/SEC)         (MIN)

                0.50000        0.00000
    1                                           0.0052759          200.0000
                0.48459        0.22479
    2                                           0.0154927          170.2575
                0.46897        0.43522
    3                                           0.0251661          112.3597
                0.45265        0.62721
    4                                           0.0342811           86.7527
                0.43548        0.80134
    5                                           0.0428171           72.2735
                0.41736        0.96037
    6                                           0.0507523           62.9993
                0.39820        1.10613
    7                                           0.0580688           56.5966
                0.37791        1.23974
    8                                           0.0647604           51.9590
                0.35633        1.36183
    9                                           0.0708180           48.4963
                0.33327        1.47263
   10                                           0.0762199           45.8665
                0.30844        1.57190
   11                                           0.0809417           43.8479
                0.28140        1.65935
   12                                           0.0849569           42.2856
                0.25151        1.73453
   13                                           0.0882575           41.0832
                0.21760        1.79675
   14                                           0.0908484           40.1870
                0.17740        1.84489
   15                                           0.0927242           39.5437
                0.12506        1.88293
   16                                           0.0933690           38.9619
                0.00000        1.92022

THE RENOLDS NO. IS 0.70850658E 03 .
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THE AGE OF FLOW IS  200.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  32 .

AT   4915.100  FEET, THE PRESSURE GRADIENT IS 0.0007875 LB/SQ IN/FT.

 RADIAL                                               RADIAL        AGE AT CENTRE
INCREMENT        RADIUS         VELOCITY       INCREMENT FLOW   OF INCREMENT
   NO.            (FT)          (FT/SEC)         (CU FT/SEC)        (MIN)

                0.50000         0.00000
    1                                           0.0052759          200.0000
                0.48409         0.21755
    2                                           0.0154927          200.0000
                0.46806         0.42321
    3                                           0.0251661          164.4254
                0.45147         0.61732
    4                                           0.0342811          125.3000
                0.43413         0.79614
    5                                           0.0428171          103.4086
                0.41594         0.95980
    6                                           0.0507523           89.4657
                0.39678         1.10942
    7                                           0.0580688           79.8632
                0.37652         1.24605
    8                                           0.0647604           72.9088
                0.35501         1.37037
    9                                           0.0708180           67.7053
                0.33204         1.48286
   10                                           0.0762199           63.7360
                0.30732         1.58372
   11                                           0.0809417           60.6729
                0.28042         1.67278
   12                                           0.0849569           58.2936
                0.25069         1.74971
   13                                           0.0882575           56.4577
                0.21702         1.81378
   14                                           0.0908484           55.0869
                0.17716         1.86376
   15                                           0.0927242           54.0880
                0.12545         1.90551
   16                                           0.0933690           53.1532
                0.00000         1.94724

THE RENOLDS NO. IS 0.73157812E 03 .
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THE AGE OF FLOW IS  200.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  33 .

AT   6553.500  FEET, THE PRESSURE GRADIENT IS 0.0007722 LB/SQ IN/FT.

 RADIAL                                           RADIAL      AGE AT CENTRE
INCREMENT       RADIUS         VELOCITY       INCREMENT FLOW  OF INCREMENT
   NO.           (FT)          (FT/SEC)        (CU FT/SEC)       (MIN)

               0.50000         0.00000
    1                                           0.0052759        200.0000
               0.48374         0.21357
    2                                           0.0154927        200.0000
               0.46729         0.41569
    3                                           0.0251661        200.0000
               0.45030         0.61004
    4                                           0.0342811        163.9939
               0.43269         0.79191
    5                                           0.0428171        134.4924
               0.41434         0.95918
    6                                           0.0507523        115.8033
               0.39509         1.11222
    7                                           0.0580688        102.9762
               0.37480         1.25164
    8                                           0.0647604         93.7028
               0.35328         1.37824
    9                                           0.0708180         86.7639
               0.33033         1.49291
   10                                           0.0762199         81.4603
               0.30564         1.59581
   11                                           0.0809417         77.3562
               0.27880         1.68681
   12                                           0.0849569         74.1613
               0.24914         1.76549
   13                                           0.0882575         71.6913
               0.21554         1.83116
   14                                           0.0908484         69.8439
               0.17576         1.88265
   15                                           0.0927242         68.4792
               0.12412         1.92755
   16                                           0.0933690         67.1659
               0.00000         1.97189

THE RENOLDS NO. IS 0.74611302E 03 .
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THE AGE OF FLOW IS  200.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  34 .

AT   9830.300  FEET, THE PRESSURE GRADIENT IS 0.0007545 LB/SQ IN/FT.

 RADIAL                                              RADIAL        AGE AT CENTRE
INCREMENT          RADIUS          VELOCITY     INCREMENT FLOW   OF INCREMENT
   NO.              (FT)           (FT/SEC)       (CU FT/SEC)        (MIN)

                  0.50000          0.00000
    1                                              0.0052759          200.0000
                  0.48335          0.20871
    2                                              0.0154927          200.0000
                  0.46649          0.40607
    3                                              0.0251661          200.0000
                  0.44905          0.59597
    4                                              0.0342811          200.0000
                  0.43101          0.77765
    5                                              0.0428171          197.1403
                  0.41232          0.94997
    6                                              0.0507523          168.5980
                  0.39285          1.10910
    7                                              0.0580688          149.1182
                  0.37244          1.25464
    8                                              0.0647604          135.0924
                  0.35088          1.38689
    9                                              0.0708180          124.6164
                  0.32794          1.50646
   10                                              0.0762199          116.6045
                  0.30332          1.61356
   11                                              0.0809417          110.3937
                  0.27659          1.70820
   12                                              0.0849569          105.5505
                  0.24708          1.79014
   13                                              0.0882575          101.7993
                  0.21369          1.85883
   14                                              0.0908484           98.9843
                  0.17419          1.91375
   15                                              0.0927242           96.8581
                  0.12298          1.96360
   16                                              0.0933690           94.7399
                  0.00000          2.01279

THE RENOLDS NO. IS 0.76367079E 03 .
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THE AGE OF FLOW IS  200.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  35 .

AT  13107.100  FEET, THE PRESSURE GRADIENT IS 0.0007447 LB/SQ IN/FT.

 RADIAL                                            RADIAL        AGE AT CENTRE
INCREMENT        RADIUS        VELOCITY      INCREMENT FLOW   OF INCREMENT
   NO.            (FT)         (FT/SEC)       (CU FT/SEC)          (MIN)

                0.50000        0.00000
    1                                          0.0052759          200.0000
                0.48313        0.20603
    2                                          0.0154927          200.0000
                0.46603        0.40076
    3                                          0.0251661          200.0000
                0.44833        0.58807
    4                                          0.0342811          200.0000
                0.43002        0.76722
    5                                          0.0428171          200.0000
                0.41102        0.93785
    6                                          0.0507523          200.0000
                0.39127        1.09962
    7                                          0.0580688          195.3452
                0.37065        1.25143
    8                                          0.0647604          176.3652
                0.34897        1.38959
    9                                          0.0708180          162.2335
                0.32599        1.51449
   10                                          0.0762199          151.4418
                0.30138        1.62640
   11                                          0.0809417          143.0790
                0.27472        1.72533
   12                                          0.0849569          136.5572
                0.24533        1.81108
   13                                          0.0882575          131.5025
                0.21210        1.88310
   14                                          0.0908484          127.6981
                0.17284        1.94119
   15                                          0.0927242          124.7773
                0.12199        1.99495
   16                                          0.0933690          121.8083
                0.00000        2.04789

THE RENOLDS NO. IS 0.77371173E 03 .
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THE AGE OF FLOW IS  200.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  36 .

AT  19660.700  FEET, THE PRESSURE GRADIENT IS 0.0007381 LB/SQ IN/FT.

 RADIAL                                    RADIAL      AGE AT CENTRE
INCREMENT      RADIUS      VELOCITY    INCREMENT FLOW  OF INCREMENT
   NO.         (FT)        (FT/SEC)      (CU FT/SEC)        (MIN)

               0.50000     0.00000
    1                                    0.0052759         200.0000
               0.48297     0.20428
    2                                    0.0154927         200.0000
               0.46572     0.39720
    3                                    0.0251661         200.0000
               0.44784     0.58279
    4                                    0.0342811         200.0000
               0.42934     0.76023
    5                                    0.0428171         200.0000
               0.41013     0.92915
    6                                    0.0507523         200.0000
               0.39014     1.08925
    7                                    0.0580688         200.0000
               0.36925     1.24015
    8                                    0.0647604         200.0000
               0.34732     1.38103
    9                                    0.0708180         200.0000
               0.32411     1.51131
   10                                    0.0762199         200.0000
               0.29936     1.63041
   11                                    0.0809417         207.9376
               0.27263     1.73836
   12                                    0.0849569         197.9046
               0.24329     1.83232
   13                                    0.0882575         190.1340
               0.21021     1.91108
   14                                    0.0908484         184.2723
               0.17121     1.97471
   15                                    0.0927242         179.6846
               0.12080     2.03452
   16                                    0.0933690         174.9174
               0.00000     2.09336

THE RENOLDS NO. IS 0.78059609E 03 .
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THE AGE OF FLOW IS  200.0000  MIN.

THE INCREMENT NUMBER IN LENGTH IS  37 .

AT  26214.300  FEET, THE PRESSURE GRADIENT IS 0.0007379 LB/SQ IN/FT.

 RADIAL                                          RADIAL      AGE AT CENTRE
INCREMENT           RADIUS      VELOCITY    INCREMENT FLOW  OF INCREMENT
   NO.               (FT)       (FT/SEC)     (CU FT/SEC)       (MIN)

                   0.50000      0.00000
    1                                         0.0052759        200.0000
                   0.48297      0.20420
    2                                         0.0154927        200.0000
                   0.46571      0.39712
    3                                         0.0251661        200.0000
                   0.44783      0.58266
    4                                         0.0342811        200.0000
                   0.42932      0.76006
    5                                         0.0428171        200.0000
                   0.41011      0.92896
    6                                         0.0507523        200.0000
                   0.39011      1.08902
    7                                         0.0580688        200.0000
                   0.36922      1.23987
    8                                         0.0647604        200.0000
                   0.34727      1.38071
    9                                         0.0708180        200.0000
                   0.32406      1.51094
   10                                         0.0762199        200.0000
                   0.29929      1.62999
   11                                         0.0809417        200.0000
                   0.27254      1.73711
   12                                         0.0849569        200.0000
                   0.24317      1.83132
   13                                         0.0882575        200.0000
                   0.21007      1.91130
   14                                         0.0908484        200.0000
                   0.17106      1.97646
   15                                         0.0927242        200.0000
                   0.12065      2.03817
   16                                         0.0933690        200.0000
                   0.00000      2.09927

THE RENOLDS NO. IS 0.78076582E 03 .
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THE AGE OF FLOW IS  200.0000  MIN.

                 DISTANCE FROM ENTRANCE           PRESSURE
                         (FEET)                  (LB/SQ IN)

                          0.000                   0.00000
                          0.100                   0.00031
                          0.300                   0.00092
                          0.700                   0.00216
                          1.500                   0.00462
                          3.100                   0.00689
                          6.300                   0.01035
                         12.700                   0.01729
                         25.500                   0.03096
                         51.100                   0.05796
                        102.300                   0.11159
                        204.700                   0.21674
                        409.500                   0.42041
                        819.100                   0.80331
                       1638.300                   1.52750
                       3276.700                   2.89636
                       6553.500                   5.48262
                      13107.100                  10.43569
                      26214.300                  20.12402
                      52428.699                  39.46849
                     104857.498                  78.15741
                     209715.096                 155.53527
                     419430.293                 310.29098
                     528000.000                 390.40812


WITH  528000.0  FT., THE DROP IN PRESSURE IS  390.4081  LB/SQ IN.
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